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THE GEOLOGICAL HISTORY OF THE OREODONTS

BY MALCOLM RUTHERFORD THORPE

[*Plates 6–7*]

The oreodonts comprise a group of nearly 30 genera and more than 100 species of exclusively North American mammals. They are wholly extinct and are neither represented by, nor closely related to, any living form.

The general appearance of a typical specimen of this family is that of an animal having a long body, short legs, short neck, and large head. They ranged in size from about that of a large domestic cat to that of a wild boar. They were primarily herbivorous, but I have no doubt that on occasion they were flesh-eaters as well, as the pigs and wild hogs are today. They must have subsisted mainly on roots and tubers, leaves, young shoots, and swamp vegetation.

The oreodonts were artiodactyls, and, from a careful study of the brain casts of several species, it is apparent that the stem stock had a curious combination of suilline and ruminant characters.

As to the dispersal of the various members of this group, we find the first of the line in the strata of the Upper Eocene (Uinta) of Wyoming, and there are but two genera. From this humble beginning, they spread westward to the Pacific Coast and eastward nearly to the Mississippi Valley, southward as far as the Mohave region of southern California, and northward to Oregon and Montana.

The geologic range shows a considerable expansion and development in the Oligocene—in fact here was the culmination in point of numbers

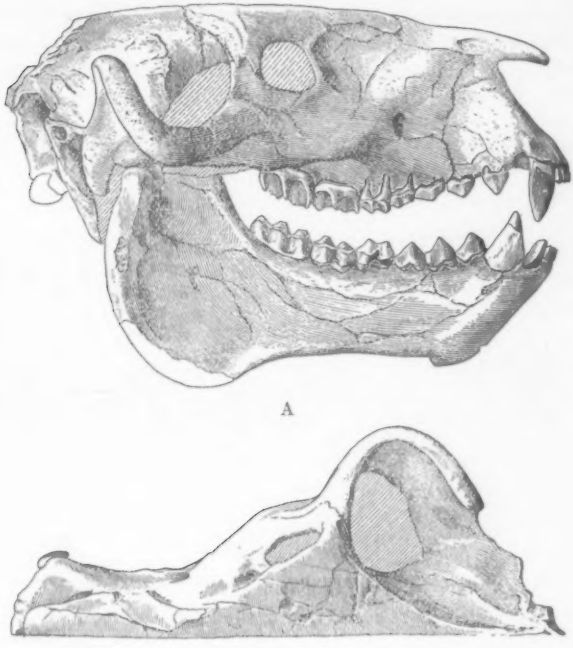
of individuals, whereas the Miocene witnessed the greater diversity of generic differentiation. By the end of this time there had developed six distinct phyla, and early in this period we see the approach of the terminal forms, which forecast the extinction of this entire family. In the early Pliocene there are still some survivors, but by the end of early Middle Pliocene, perhaps before, they have completed their course and have vanished from the face of the earth.

Of the ancestors of this group we know but little. No remains of mammals which would seem to be ancestral have been found in strata earlier than the Uinta and all the evidence indicates that the oreodonts were immigrants, and not indigenous. Throughout Eocene time there was a struggle between the native and immigrant mammals for supremacy, and the latter finally won out, due in part to their superior mental equipment. Whence the oreodonts came, then, is an open question. When we examine the European fauna of the Eocene, we find a similarity in the dentition of the anthracotheres and their relatives, the semiselenodont artiodactyls, known as the ancodonts, or hyopotamids. But while many of these European forms became extinct at the close of the Eocene, they were too specialized to have been ancestral to the American oreodonts. However, the European and American forms probably had a common ancestral stock, inhabiting a north Asiatic area (the Holarctic continent Eris), whose fauna spread southward and westward, to give rise to the Old and New World forms. In the light of present knowledge this seems to be the most probable theory of the early oreodont relationships. On the other hand we see structural affinities with the primitive camels, and we must remember that the camels, true tapirs, entelodonts, and other forms, appeared in North America during the late Eocene, together with the oreodonts. This fauna was apparently an upland or mountainous one. North and South America were likewise united during much of earlier Eocene, but there are no indications of affinities between the oreodonts and the South American faunas.

Let us now consider a few of the genera of this important group. In the Upper Eocene, we first meet with *Protoreodon* and *Protagriochœrus*, the oldest and most primitive members of the family so far known. Even at this early date, the lower canine has ceased to function as such and its place has been taken by the first premolar. This is true of every succeeding genus in the family. The molar teeth indicate their derivation from conical cusps, for the crescents are thicker and more rudimentary. There is also a small fifth cusp between the anterior pair of the

upper molars, which is not found in any later genera. There were five toes on the manus and probably on the pes.

At least eight genera became well differentiated in the Oligocene. Today members of some of the genera are among the commonest of mammalian fossils. Oreodonts must have lived in immense herds in the



A

B

FIG. 1. PROMERYCOCHŒRUS MARSHI THORPE

Holotype, Cat. No. 10999, Y. P. M. A, right lateral view of skull and jaw; B, right half, superior view. × ¼.

forests and along the stream courses, although many undoubtedly inhabited the higher lands. The stem stock was continued in *Merycoidodon* (plates 6 and 7), from which it seems that nearly all the subsequent genera diverged. The annectant forms, however, in some instances have not yet been discovered. From the typical cursorial

oreodont, *Merycoidodon*, *Eporeodon* developed in the upper White River. This same genus is found also in the John Day Basin of Oregon, showing that dispersal had already progressed to a considerable extent. *Promerycochœrus* (fig. 1) of the Upper Oligocene was the largest of the entire family, although some of the species were of only moderate size. In the Great Plains, this latter genus and *Leptauchenia* continued into the Miocene, while the end of the Oligocene saw a complete extinction of all the oreodonts in the John Day Basin. Hence we find three distinct phyla, (1) the stem stock, the typical browsing or grazing oreo-

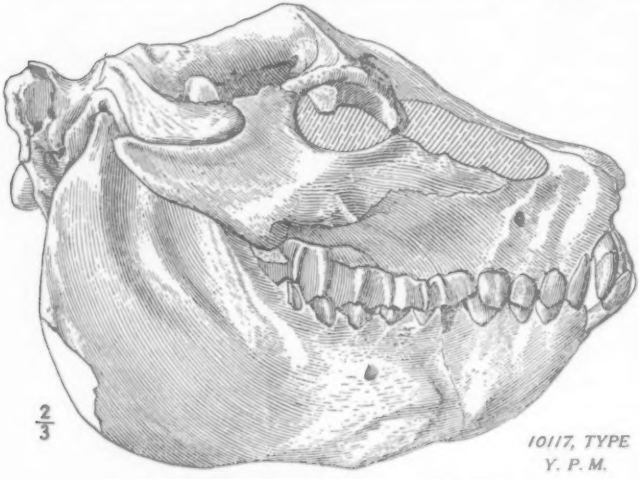


Fig. 2. Cyclopidius lullianus Thorpe
Holotype. Lateral view of skull and jaw. × ⅔

donts; (2) the river-border or forest-living, and maybe tree-climbing *Agriochœrus*, which survived nearly to the Miocene, both in the Great Plains and in the John Day Basin, but became wholly extinct in the Upper Oligocene; and (3) the small brachycephalic, plains-dwelling *Leptauchenia*.

The late Oligocene and early Miocene was a very important period in the racial history of the oreodont family. The epoch from the earliest known genus through the end of the Oligocene may be termed the age of the persistence of primitive characters; that between early Miocene and the extinction of the last of the group, the age of specialization. It

was the period of change from browsing to grazing types, while the river-border and forest-living oreodonts were on the wane and became extinct before the end of the epoch.

That this differentiation had already begun in the Upper Oligocene is seen in the genus *Leptauchenia*. These were small peculiar animals, with a low flattened skull and deep robust jaws. This genus appears suddenly, and we know of no form connecting it with the stem stock of the family. Were the oreodonts not confined entirely to this country, there would be very little hesitancy on the part of paleontologists to ascribe this sudden appearance to immigration. However, this is not

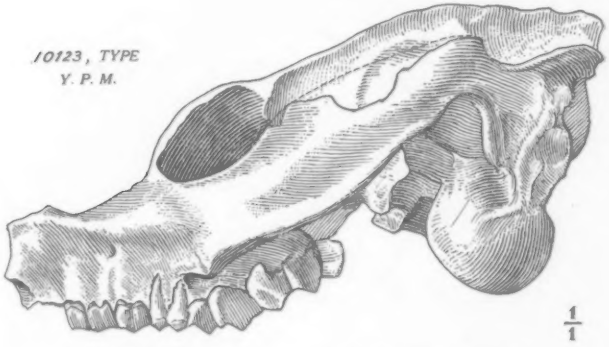


FIG. 3. CHELONOCEPHALUS SCHUCHERTI THORPE
Holotype. Lateral view of skull. × 1

probable, and the evidence indicates that *Leptauchenia* branched off in the Middle or Lower Oligocene, but has left no trace so far discovered of its early evolution.

Leptauchenia probably gave rise to *Cyclopidius* (fig. 2), which possesses, in an exaggerated form, the various peculiarities of its earlier representative. It had larger nasal vacuities, and was a somewhat larger and more robust animal. The face is shortened and the eye-sockets elevated, while the ear has more fully developed the tubular entrance. These features indicate an aquatic or amphibious mode of life, after the manner of the hippopotami. The teeth were completely hypsodont. This *Leptauchenia-Cyclopidius* phylum makes its last appearance in the Middle Miocene, represented by a third genus, so far known from but one specimen, which I described in 1921, giving it

the name *Chelonocephalus* (figs. 3 and 4). It undoubtedly belongs to the *Cyclopidius* phylum and yet may not be a derivative of that genus. It has attained a maximum of skull foreshortening, together with a proportionally extreme width.

In the Great Plains, *Promerycochœrus* held over into the Miocene, and it is believed that this genus gave rise to *Merycochœrus*, which reached a maximum size of about that of a large domestic pig. The face was greatly shortened and the nasal bones much reduced, while the eye-sockets were placed high on the head and looked forward and upward,

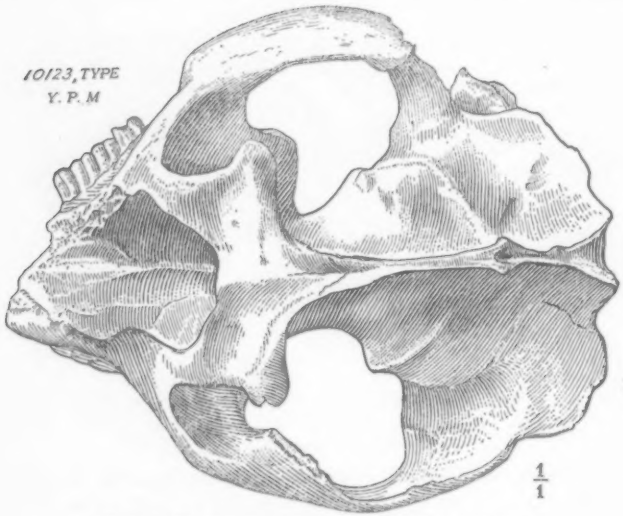


FIG. 4. CHELONOCEPHALUS SCHUCHERTI THORPE
Holotype. Superior view. × 1

instead of laterally, the normal position in this group. Here again we probably have an aquatic adaptation. We also have undoubted indications that *Merycochœrus* had a short proboscis. The terminal and most highly specialized member of this group was *Pronomotherium* (fig. 5), found in Montana, in which the face was excessively shortened and the nasals greatly reduced, thereby leading us to the conclusion that its proboscis was much more developed than that of *Merycochœrus*, its probable ancestor. It is worthy of note that in this case the ancestral

form and its derivative continued to live on side by side. The new and specialized oreodonts, *Mesoreodon* and *Phenacocœlus*, also appear for the first time in the lower Miocene. *Merychyus*, *Merycochœrus*, and *Metoreodon* were the last survivors of the family and held over into the early and possibly Middle Pliocene.

Let us briefly review the evolutionary history of these animals. We have seen that they underwent many transformations, some resulting in bizarre forms, and yet the changes were confined almost wholly to the teeth and skull, while the remainder of the skeleton remained nearly

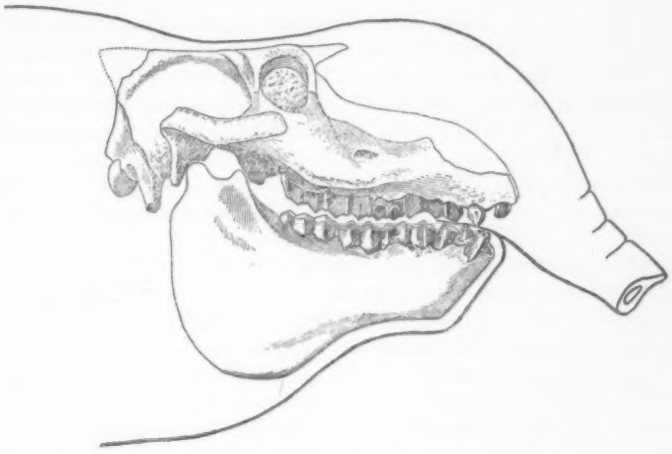


FIG. 5. PRONOMOTHERIUM ALTIRAMUM (DOUGLASS)

Flesh restoration by Professor Lull. (Skull and jaw modified from Douglass.) × ⅛.

static. We should note also that early in their history the digits were reduced from five to four, first in the pes and then in the manus, and there reduction ended. This localization in the skull of evolutionary changes is unusual, although something of the same sort occurred in the tapirs and elephants. However, the more usual result is that all parts are modified, as may be seen in the phylogenetic history of the horses, rhinoceroses, titanotheres, and others. There was a general increase in size, but irregular in development and varying greatly, even within a genus. The superior molars lost the fifth cusp before the first Oligo-

cene form of which we know, and from thence on there was very little tooth change, except for the development of hypsodonty.

The modifications in the skull were varied and numerous. The orbit was open posteriorly in the Eocene, and in one Oligocene genus, *Limnenetes*. In the *Promerycochœrus-Pronomotherium* phylum, the skull first enlarged and the face elongated; then the face and nasals became progressively shortened with the development of a proboscis. In the *Leptauchenia* phylum the skull became flattened, the face developed large vacuities, and the ears and eyes were elevated.

Geologic conditions—The first horizon where oreodonts appear is the Upper Eocene Uinta formation in western Wyoming. This formation has a thickness of about 300 feet and is composed of much volcanic ash and debris. The close of Fort Union time witnessed the final movement in the upthrusting of the Laramide Mountains (practically the Rocky Mountains), and from thence on eruptions, chiefly of an explosive nature, continued through the Eocene and Oligocene, though with progressively diminishing force in that region. In the late Eocene there was again a return of a mild, moist climate and much of the land lay near sea level.

In the Oligocene, the climate continued warm and often moist, with a prevalence of forests similar to those of the Eocene, with palms, figs, planes, hickories, and hackberries. Hence the browsers constituted the majority of the fauna, although here for the first time we find grazing animals of the open plains. There are hence the lowland and upland forms, the latter cursorial types, as horses and camels. The river channel sandstones bear the remains of the forest—and river-living animals, whereas the clays and fine sandstones have the plains-living and cursorial forms. In the early part of this epoch there was a short period of interchange between Europe and North America.

The lands were now peneplained and the interior of this country, having broad eastward slopes from the Rocky Mountains, was a vast and nearly uniform plain, over which the streams meandered widely. Consequently the origin of the deposits was mainly fluviatile, flood-plain, river-channel, and æolian. There were also backwater, lagoon, and shallow lake conditions. The materials were largely erosion products from the Rocky Mountains and the Black Hills, together with an ever increasing amount of volcanic debris. Limestone and gypsum layers were also occasionally laid down.

Some of these channels of the great eastward-flowing steams were from 700 feet to a mile in width. Occasionally the rivers overflowed and

formed broad, shallow sheets of water, much as does the Nile today. These were too ephemeral to support an aquatic fauna. In general we may assume that savannahs were intermingled with grass-covered pampas.

In the Upper Oligocene of Oregon, there was developed an intermontane formation, of between 3000 and 4000 feet of volcanic ash and tuffs. This is known as the John Day. The deposit is probably æolian chiefly, although there may have been shallow, shifting lakes. In the latter part of the period of deposition, the streams became more active, due to orogenic movements.

During the Oligocene we have seen that the general climatic and physiographic conditions were fairly favorable for the fauna and flora. In the Miocene these conditions became less favorable, and a drier and cooler climate developed, partly due to an upthrusting in the Rocky Mountain area, and the breaking down of the continent Eris in the middle of this epoch, whereby the colder Arctic currents came down along the Atlantic seaboard. More or less desert conditions developed in the Cordilleran region and have prevailed there to the present. The forests were considerably reduced in areal extent, and this epoch as a whole, but particularly the latter part, was characterized by a decided increase in grass-covered plains, which caused a great change in food conditions for the fauna.

The Cascadian Revolution began in the Middle Miocene and still continues. The highlands of eastern Washington and Oregon were formed and the second period of uplift of the Coast Range of California was initiated. Active volcanoes were numerous. The northern areas of depostion show that their strata were largely composed of altered or eroded volcanic ash, and in some places layers of pure ash are found. There was another faunal interchange in Deep River time by way of Siberia and Alaska, when the rhinoceroses and elephants came from Asia and Africa, and another intermigration between North and South America in the late Miocene.

There is no sharp line of demarcation in the sedimentary record between the Oligocene and Miocene, and yet there are indications of a long period of erosion and of great environmental changes between these two epochs. The gentle easterly slopes were still present; the great flood plains cut by numerous streams.

On the West Coast mountains and around Florissant Lake, Colorado, there prevailed a south temperate climate, with sufficient moisture, but not continuously humid. Forests of willows, poplars, oaks, elms, and

other trees grew in those areas. It was predominantly a hardwood flora and yet it had a southern character. Florissant Lake, of either Middle or Upper Miocene age, lay in a valley, surrounded by volcanoes, and the sediments are wholly of volcanic sand and ash. More than 100 genera of plants, many of which still live in Colorado, have been described from these strata.

Between the Miocene and Pliocene again there is no marked separation in the sedimentary record, for the general trend of geologic events progresses into the latter period. The orogenic movements continued until North America was more emergent than at any other epoch of the Cenozoic, and this resulted in a more arid and much cooler climate. The whole of the Cordilleras was being elevated, and the contraction of streams and the summer droughts were becoming more and more prevalent. Great numbers of land tortoises were present, and the aspect of the land was that of an open, relatively arid country. It is significant that the rhinoceroses, browsing horses, and browsing camels disappeared at this time. Another faunal interchange, greater than any previous one with South America, took place in this epoch.

In the third and last part of this paper we shall consider the reaction of the oreodonts to their environment, confining our attention chiefly to the causes of their extinction. These causes will be discussed under the following heads: Climatic and territorial influences, insects, predatory animals, vulcanism, and the inherent inability of the animals to become adapted to a changed and changing environment. Many other influences have doubtless contributed to the final result, but we shall confine our attention to these more prominent ones. Very rarely does a single influence produce extinction, for there is almost always a combination of circumstances of varying potency, so that the causes dovetail together, and the interrelationship and interdependency of an environmental and internal complex are realized only upon careful analysis.

Taking up first the *climatic influences*, we find a progressively cooler climate, due to elevation of the land in the Miocene and Pliocene, which caused a whole train of concomitant phenomena. Greater aridity prevailed, with a reduction of stream courses, and this reacted unfavorably upon those oreodonts, as *Leptauchenia*, which were aquatic, or at least amphibious. Also this naturally produced changes in the amount of forest cover, increased meadow and savannah areas, and altered the kind of vegetation. This cooler climate and increasing aridity favored the development of harsher, more resistant vegetation, such as the grasses. It also caused deforestation, removing forest barriers and

admitting new competitors. With an increasing length and severity of dry seasons, it became necessary for the animals to travel widely in search of food and water. This exposed the fauna to predatory animals, both in the open and at the more or less restricted water holes, and streams. Hence it is clear that droughts very seriously disturb the balance of nature. This change of diet may have induced the animals, through hunger, to turn to poisonous plants as a source of food, in their attempt to adapt themselves, and thus there may have resulted a diminution in the number of individuals in a group without extinction, or the group may have become weakened from the physiological effects of these plants which may have been rather numerous around the water holes, as moisture favors the growth of these types. It may be that the winters of the Miocene were sufficiently severe to bury the grassy areas, in which case the various groups probably reacted differently, as they do today. For example, horses have been known to dig through three or four feet of snow for food, whereas cattle under the same circumstances starve to death. Again, periods of cold often disarrange reproduction, the effects being seen in impoverished females, in inclement weather at time of birth, and in other ways. A weakened condition of the herd is favorable for the increase of carnivores, especially cats and dogs. It seems reasonably certain that temperature, rather than humidity, plays a rôle of prime importance in delimiting areas where reproduction can take place. Periodic flooding of areas, as occurred during and after the Oligocene, likewise probably caught and engulfed many animals.

The increase of numbers of individuals, or *overcrowding*, in a restricted area may greatly disturb the balance of nature, by altering the character and the amount of the food supply and may even change the water supply in the region. We know that in the Oligocene, the oreodonts and horses ranged in huge numbers, and the effect may have been comparable to the introduction of sheep on a cattle range. It seems reasonable to suppose that they helped cause the extinction of some of the larger quadrupeds, as the titanotheres, and their own extinction may have been aided by this overstocking of a given area. It probably produced a diminution of numbers, which in itself does not mean extinction, but often leads to that result. As we know, too close inbreeding will cause ultimate extinction, for finally there will not be enought adults to protect the young, or they will not have the requisite physical vigor to compete with predatory animals and stress climates. These small browsing animals contributed to deforestation by the destruction of young trees.

Darwin has said that the keenest competitors are the animals of most nearly similar feeding habits, and this competition would rapidly increase with the numerical growth of individuals, as we know occurred in the Oligocene. Another form of competition was caused by the introduction of new faunas, which took place in nearly all of the Cenozoic epochs. It is almost always the native fauna which gives way before the immigrants.

As the drier climate increased, certain more moist areas became more and more sought, and there was more of a concentration of fauna at or near these places. In these areas poisonous plants probably grew and were eaten as above mentioned, but, in addition, many of these places were probably infested with *insects*, which carried protozoan diseases. Today, as undoubtedly in the past, certain areas have been rendered uninhabitable, as by the ticks among horses, and certain larvæ which enter the skull sinuses. More than 6000 species of insects are known from the American Cenozoic and some have changed practically not at all. For example, there were two species each of the horse fly and of the tse-tse fly, which lived in the Miocene in Colorado, and the completeness of insect development seemed to be in that epoch.

Infectious diseases are often found today among the gregarious Herbivora and probably have been prevalent in the past. While not necessarily causing extinction, they would diminish the numbers, and extinction would often follow. Immunity is one of the greatest of animal adaptations to environment, but those that attain immunity, while they themselves survive, yet often act as reservoirs from which the insects replenish their poisons, and which in turn are passed on to the non-immune fauna.

It is not inconceivable that some insects may have destroyed the vegetation over large areas, as the locusts do today, thus working much hardship on the faunas.

Carnivores undoubtedly took heavy toll of these small oreodonts, especially as the latter had no adequate means of defense nor of flight. Their keen sense of smell and of sight was their chief means of preservation against predatory animals, but their general life habits were based on a complex of reflexes, with very little volitional activity on the part of the individual. They were especially prone to attack in the open country and around the water holes. Today large numbers of the young of the peccaries are killed by predatory animals. As the herds lost vigor, the carnivores waxed stronger, and doubtless many an oreodont, both young and old, fell a victim.

A few years ago, I made a quantitative study of several hundred specimens of the Great Plains *Merycoidodon* and the John Day *Eporeodon* for the purpose of determining the relative age of the individuals at death. There is a remarkable agreement between these two genera, so widely separated geographically and in time, as well as in environmental conditions. The result of these studies showed that 65.7 per cent in the Great Plains died in the prime of life, and 65.6 per cent in the John Day Basin. In the former area 20.9 per cent died before maturity and in the latter, but 13.2 per cent, indicating a higher rate of infant mortality in the Great Plains *Merycoidodon*. Of those that reached a ripe old age, only 3.3 per cent are recorded from the Great Plains and 8.8 per cent in the John Day. Ten per cent died in the Great Plains between maturity and the beginning of old age and 12.2 per cent in the John Day. Therefore it would seem that over 95 per cent of the Great Plains oreodonts never reached old age, while in the John Day Basin, somewhat more isolated perhaps, about 85 per cent died before old age. Needless to say, we cannot attribute all of these early deaths to carnivores, but they undoubtedly played a considerable part, as their remains are fairly plentiful and differentiated in both of these areas in the Oligocene.

Vulcanism and volcanic activity were fairly common phenomena throughout Oligocene and Miocene times in western North America. In fact, volcanic ash is present in nearly all the strata of these two periods and in some formations is the dominant constituent. Matthew has expressed the belief that volcanic ash is "almost the principal source of terrestrial sediments in the Tertiary formations of the West." To further illustrate the magnitude of these ash falls, we find some interesting data in a recent (1923) paper by Wanless. Grigg's work on the Mount Katmai eruption, which is believed to have been the greatest one known in historic times, gives an estimate of $4\frac{3}{4}$ cubic miles as the amount of material erupted, whereas the White Ash Layer in the Great Plains Upper Oligocene represents, according to Wanless, an ash fall of more than 100 cubic miles of erupted material, or over 20 times the amount from Mount Katmai. We must bear in mind, moreover, that the White Ash Layer is but one of many formations bearing large amounts of volcanic debris. The John Day formation is another example, several thousand feet thick and composed almost wholly of ash or volcanic agglomerates.

Now what may have been the influence of these great ash falls? Primarily it seems probable that they would, in fact actually did in the John Day Basin, bury and thereby destroy much vegetation over con-

siderable areas. This would cause another set of conditions to operate, such as restricted areas, overcrowding, and other combinations, with their resultant effects. Likewise sudden ash falls may have overwhelmed many of the oreodonts and other animals. The four specimens of *Promerycochœrus*, found huddled together, by Peterson some years ago in Nebraska, seem to have met death in this manner. Another point to consider is that these animals were all of short stature, and that maybe they were overcome in crossing certain gas-filled areas.

There are certain *internal causes* of extinction which the oreodonts possessed. For example, the teeth are short-crowned in all genera before the Miocene, and only three genera thereafter attain the complete hypsodont condition. This brachyodont tooth could not withstand the wear caused by the harsher herbage of the late Oligocene and Miocene. This would seem to have been a potent contributary cause of extinction of *Agriochœrus*, *Merycoidodon*, *Eporeodon*, and *Promerycochœrus*. The brachyodont horses and camels also disappeared at approximately the same time as the oreodonts. The harsher herbage consisted largely of grasses which had a high silica content, and also bore much dust and foreign matter.

Another influence is the inadaptive foot structure, which prevented the carpals and metacarpals from elongating into cannon bones and making the animal truly cursorial like the horse. The oreodonts never attained this and they never reduced the number of digits below four. Consequently they could not flee very rapidly from their enemies, nor cover long distances to water or food with any degree of speed.

Yet another cause of extinction is the extreme specialization which we see in the *Leptauchenia-Chelonocephalus* phylum, and in the *Merycochœrus* line. The oreodonts never possessed more than a moderate sized brain, and this may have hampered them in resourcefulness in periods of stress, in finding new habitats, and in avoiding dangers to which young and old may have been exposed.

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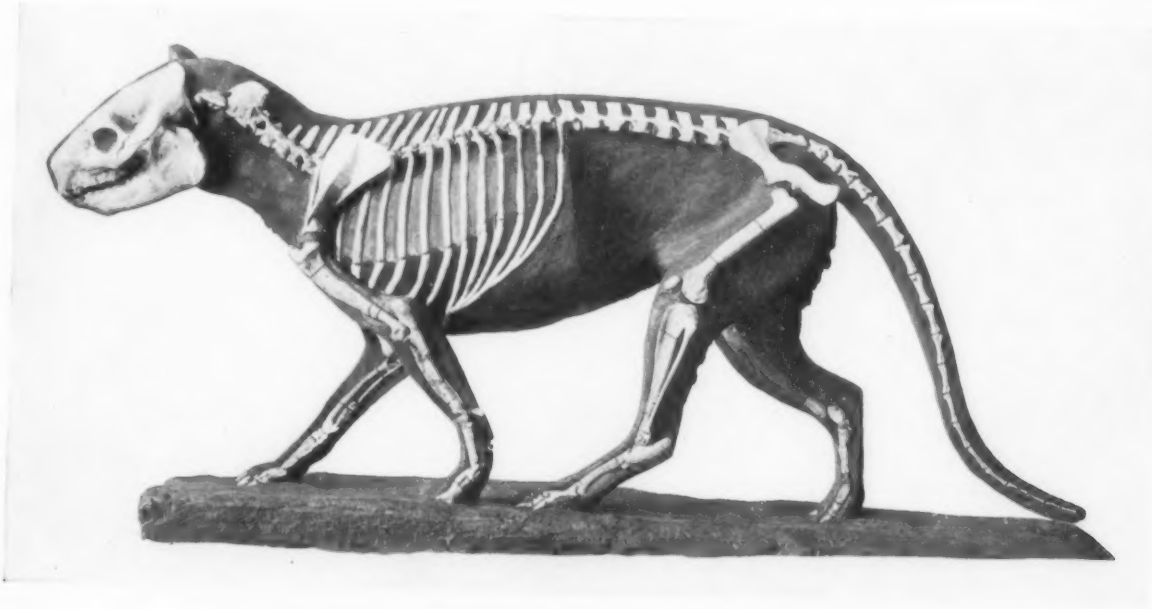

MERYCOIDODON GRACILIS (LEIDY)
Skeletal aspect. Mounted in the Peabody Museum of Natural History. × ⅛.

(Thorpe: The Geological History of the Oreodonta)

MERYCOIDODON GRACILIS (LEIDY)
Flesh restoration, by Professor Lull, of same individual as shown in Plate 6. × ⅛.
(Thorpe: The Geological History of the Oreodonts)

THE CONSERVATION OF PREDATORY MAMMALS[1]

By Dr. Charles C. Adams

STATUS OF THE PROBLEM

In primeval America, before the advent of the Indian, there was a strictly "original" condition, and there has been relatively little since then. With the arrival of the Indian, probably with his dogs, new predators were added to the fauna, and the overturning of the original pre-human relative balance of nature was begun. Wissler ('22, pp. 1–44) has pointed out and mapped the food areas occupied by Indians and the Eskimos of the North with their dogs. Here they preyed upon caribou, seals and salmon. Upon the Great Plains the Indians lived upon the buffalo; while those of the remainder of the continent were mainly dependent upon vegetable foods, supplemented, of course, by a varying amount of fish and game. Thus the predatory habits of the Indians were much more pronounced to the north, and less so to the south.

The Indian population was uneven in its concentration and there were considerable cultural differences among them, so that their influence upon the fauna was probably not at all uniform. Speaking in broad, general terms, the Indian seems to have attained a general balance with the fauna, because his culture was relatively stable, and thus the conditions became quite different from those existing previous to his arrival. Such considerations as these indicate that there was a gross relative balance of nature during the Indian days, and that there were many local variations or minor differences in this balance. The chances are that these were due to local differences in the density of the population, as well as to local geographic influences, the climate, other physical features, vegetation, the animals, and finally to the competing differences among the Indian cultures themselves.

Later the Europeans arrived, slowly at first, but soon in rapidly increasing numbers, and great changes took place. This meant a change of race, other human cultural systems, certain domestic animals, and their hangers-on. The adventurers and trappers invading the North put a new value on the fur-bearing predators and rodents. At once the exploitation of this resource was expanded under the impulse of a keenly

[1] Read at the Sixth Annual Meeting of the American Society of Mammalogists, held at Harvard University, April 15, 1924.

competitive system and the old "relative balance of nature" of Pre-Columbian days was soon gone forever. Farther south the farmer-hunter-trapper pioneer pushed settlements and agriculture forward, by clearing away the wilderness and the forest and prairie haunts of wild life, and restricted their habitat. He thus initiated the process of adjustment toward a new balance, suitable for the European. Still farther south gold seekers and propagandists made strenuous efforts to change the Indian culture but they were not so successful as permanent occupants, and the overturning has not been so complete. But everywhere the new transformation has now long been under way.

In the United States our institutions have grown up upon an European foundation, modified to suit the pioneer conditions of a new continent, competing with the native Indian culture in its own environment. There has been thus developed a very complex system of interacting influences in which the native animals have suffered greatly. Our methods of territorial acquisition have given us a Public Domain of great area, which it has been our policy to dispose of as rapidly as possible and, it must be said, often very foolishly indeed.

As long as there were great areas of the bountiful wilderness and of the Public Domain, wild life thrived and was given little concern except for hunting and trapping. This was the adolescent period when we spent lavishly our public inheritance of land and other resources, without much thought for the future, and without careful planning or policy. We have now largely disposed of this great bounty and have begun to feel the pinch of need, and are beginning to come to our senses. With the appropriation of the land, there later developed a great industrialization of the country, the beginning of another era that will involve a new balance between the urban and the rural problem. Many of us have grown up seeing these changes but without an appreciation of their significance and meaning. The best land is now fully occupied, and as well, considerable areas of second class land, and already the abandoned and waste land shows the reality of a new era. This era is now upon us, as has been shown by the public recognition of the conservation movement which was made a national problem by Roosevelt and Pinchot.

Bearing in mind these ideas we are in a position to see how the conservation of wild life—the fish, game and fur-bearing animals—has become enmeshed in this complicated network of economic and social life of our people. We have reached a stage where our naturalists must take a long look ahead, must begin to orient their wild life problems

in our general economic and social system, conduct research upon those problems which will aid us in their solution, and formulate definite ideals and policies which will guide naturalists, conservationists and statesmen into proper channels. The solution is not solely a problem for the naturalist, or merely a specialist, because it must be correlated with the activities of progressive students in all the allied lines of economic, social, and political work, so that his policies may give and receive aid, and be properly related to the best general policies.

The preceding account sketches the background of the tragic, losing battle of our wild life, and shows something of the numerous and powerful stresses which have enveloped it. The Indians and the Europeans and their cultural systems have exerted immense, almost crushing, pressure upon predacious animals, and they have resisted this with all the resources at their command. They have shown a spirit of resistance against such odds that it calls for admiration. Is it not fundamentally the same impulse in the animals that resists a similar one in man? To play the game fairly with these animals we will recognize all the merit possible in such opponents, and the naturalist can admire this, even though he does not as an economist.

We see that much energy has gone into the struggle of these opposing systems, and why it is so appropriate to discuss its relation to the so-called "balance of nature." This conception recognizes that in nature there are many influences or forces interacting. Stresses are being exerted, and these initiate the process of adjustment to the pressure. The continuation of pressure will in time tend toward balancing, and finally a state of relative equilibrium will be developed by the balancing of all stresses and pressures. (Cf. Adams, '13, '15 and '18, pp. 465–490.)

We may imagine these balances of almost every conceivable magnitude, from those involving any single animal function, the animal as a whole, the species, and as applicable to all sizes of animal habitats or environments. All of these exhibit stages in the process of adjustment to stresses or pressures, or that of a relative equilibrium, caused by the balancing of pressure. Thus, for example, relative over-population produces a condition of stress or pressure upon the local population and on the local environment, and this condition continues until the pressure is relieved or balanced; by dispersal of the animals, destruction of competitors, by death of the excess of population, or by other causes.

As was pointed out, the original animal population worked out its own balance; with the arrival of the Indian a new one was begun, and with the arrival of the European still another major one was started.

And it is now our problem to learn to use this knowledge to human advantage, and therefore we have the problem of the conservation of wild life, including, of course, the predators.

CONSERVATION OF THE PREDATORS

With the preceding preliminary considerations, let us now summarize the main reasons for utilizing predatory mammals for human welfare. This discussion is built on the assumption that these animals are worth preservation, *somewhere*, and the reasons for this conclusion will here be briefly summarized. As others will discuss this subject in detail I need only make a very brief mention of the outstanding factors.

Scientific value. Predacious animals play a very important rôle in the economy of nature. They have been one of the most powerful elements in preventing over-population by the herbivorous animals. However, bacteria and animal parasites take part in the same rôle, but scientifically they play a very important rôle, worthy of careful study. There are innumerable investigations, anatomical, physiological, and ecological, geographic, taxonomic, and evolutionary problems, of the greatest scientific interest and value, to be made on predatory animals. Hollister ('17) has shown that captive lions are structurally different from wild specimens and this indicates, in part, that captive specimens are not an adequate substitute for wild ones, for certain scientific studies.

Educational and social values. The results of scientific studies have already produced many conceptions of educational value. The conceptions of the parasite, the scavenger, and the predator, have considerable educational value, and are not wholly useless in their application to social relations. The educational and recreational value of predators should not be overlooked when we recall the public interest shown in all zoological gardens in bears, wolves, foxes and similar animals. The great public interest shown in high class moving pictures of predacious mammals should be recalled in this connection, because without the preservation of these animals there will be a permanent loss of such films.

Economic value. The outstanding economic value of predacious mammals is their controlling influence upon an over-population of rodents and other animals. If these predators should become exterminated the control of these other animals would have to be undertaken largely by man, as predacious birds are unlikely to be permitted to become numerous enough to play the whole rôle.

A second utility of great economic value is in the production of fur.

For quality and durability the fur of predacious animals is today among the most valuable; the fur-seal, marten, otter, mink, fox, ermine, have long been and are likely to long remain among the most desirable of furs.

Mention must be made also of the economic possibilities which have not yet been discovered. With new conditions continually arising old values are constantly changing. For years the herbivorous muskrat was not considered of much value, but now all is changed, and we can never tell when there will be such changes. The status of the silver fox has wholly changed in a generation. Recently insulin, the priceless boon to the diabetic, has been found in the liver of the predacious shark. Who knows what yet remains to be found in the numerous predacious species which will be of priceless value to man? If ignorance and economic conditions prevent the use of many mineral resources the old refuse heaps may be reworked to advantage, but in the case of organisms, if they are not preserved, and are allowed to become extinct, there is no hope whatever of recovering them. Here is the factor of safety that should not be overlooked.

METHODS OF CONSERVATION

We now come to the crucial part of this problem in conservation, the actual practice of conservation of the predatory mammals. How should this be accomplished?

In approaching all problems of the relation of natural resources to public welfare we must, sooner or later, return to the basal problem of the proper relation which should exist between the land and its people. Our wild life conservation plans have too often been conducted without adequate recognition of this basal relation. This is not unnatural when we recall that our naturalists have not given much attention to the general problem of the relation of animals to the land, as a scientific problem. The relation of birds to definite breeding areas has long been recognized, but the corresponding aspect of mammal behavior has not received much careful study. Faunal areas and censuses have, of course, received attention, but so far as known to me we have never had a careful, fundamental and comprehensive study of the whole problem of the relation of mammals to the land. We are now reaching a stage in the development of conservation policies where we urgently need just such scientific studies, so that they may be related to our economic problems, and to the broad public policies of the land. The very important marine aspect of this predatory problem is wholly omitted from this paper.

The broad principles of land classification show that these areas may

be roughly grouped in several classes or zones based upon their general physical and biological features and their relation to the human population, and these boundaries are not sharply defined. Three primary land divisions are as follows:

a. Urban, or community site lands.

b. Agricultural, or lands suitable for tillage.

c. Forest and park, or non-agricultural and wild lands.

(*a*) National and State Parks and Preserves.

(*b*) National Forests, State Forests and Game Preserves.

a. Urban lands. At a glance one sees how this classification helps to orient the predatory problem. It shows that as far as these animals are concerned we cannot expect their extensive preservation in urban and community areas, particularly the large species, because these animals will tend to prey upon domestic or other animals desired about communities. I am unable to learn that a careful, thoroughly comprehensive, and scientific study has ever been made of this as a special problem. There are certain domestic predators, such as the cat, dog, and ferret, which are a part of this general urban problem, and which will require attention in any comprehensive program.

The investigation of urban problems has made considerable progress during the last decade. We now have bureaus of municipal research, city planning commissions, and even national organizations, which are devoting considerable attention to research on the urban problems. They are now extending the methods of survey and research, which were primarily developed by the sciences of geography, geology, natural history, and engineering, to the economic and social problems of the communities. They are rediscovering for themselves, and for their point of view, facts and relations with which the sciences have long been familiar; as for example the interdependence and ultimate unity that exists between urban and rural problems. Many influences combine to make these great dynamic centers of stress radiate their influence in all directions.

b. Agricultural lands. The cultivated fields, pastures, and orchards with their domestic animals and crops provide at once an opportunity for a conflict between the farmers' interests and those of the predatory wild species on such lands. The foxes, weasels, coyotes, wolves, and similar predators, have not been harmonized, in large numbers, with the welfare of densely settled agricultural communities. Of course an isolated farm, surrounded by non-agricultural land, is a special case, just as are patches of waste, abandoned or forest land in a predominately

agricultural area. These special cases should not confuse the broad general situation. No confusion, however, should be caused by the farming of lands unsuited to that purpose.

We can expect only a limited number of predators under *intensive* agricultural conditions, depending, of course, on the degree of intensive cultivation. The proper use of predators in the areas of *extensive* agriculture is probably today one of the most important predatory problems needing careful study. In the less intensively cultivated areas the predatory animals will not only do relatively little harm, but they can do positive good in controlling rodents, and in providing an annual crop of furs; and it is in just such conditions that we should consider giving them all the protection possible. It is not only possible, but is even desirable, to maintain public sanctuaries for the preservation of these animals in favorable isolated areas. Some of the smaller predators at least may be permitted to thrive in this zone, even on small preserves.

Considerable scientific study has been made of many aspects of this problem, but we lack even today, the formulation of general principles which should govern such policies. A comprehensive plan, as to what should be done under different systems of agricultural conditions, is yet to be worked out. Probably the complexity of the problem is so great that it has discouraged all attempts at formulation. Without question here is at present the crux of the whole predatory problem, and we need the publication of all available data which influence current methods of practice. Although probably only a few millions of dollars have been spent on the destruction of game vermin, on predatory control, and on bounties, it is simply amazing how little scientific data has been published on this phase of the work. Some of this money, as there has been relatively no lack of it, should now be diverted into scientific studies, and to the formulation of wise public policies, if we are to achieve real, not apparent, success. The cat, dog, ferret, and particularly the sheep-killing dog, are a part also of this problem, and await adequate study and satisfactory control measures.

c. Forest and park lands. The non-agricultural or forest and wild lands are today, *par excellence*, the optimum for the preservation of predatory mammals, and will probably remain so in the future. Those lands in closest proximity to agricultural areas will, if they contain too many predators, naturally overflow upon the agricultural land, and cause trouble, but the more remote or wild lands need be little influenced by this factor. These non-agricultural lands may be divided into two major groups:

(*a*). National and State Park areas, where wild life in general, including predators, should be deliberately preserved in as large numbers as the conditions will permit. In National Parks predators should, of course, be preserved in large numbers, and in all extensive State Parks there should also be made some provision for them. Such areas are definitely set aside primarily for social, that is, for scientific, educational, and recreational uses, rather than for economic purposes. In such preserves a normal balance is needed between the predacious and the herbivorous animals, showing relatively natural relations. Without question our National Parks should be one of our main sanctuaries for predacious mammals, and these parks should be of sufficient size to insure the safety and perpetuity of such mammals. At present they are not numerous enough, satisfactorily located, and properly isolated by natural boundaries to make the predacious fauna safe. The grazing of domestic animals should be prohibited in order to preserve the forage for wild species, some of which should be sacrificed for the maintenance of the predators.

The whole technique of preserving wholly wilderness areas in the modern world is a very serious problem indeed (Adams, Proc. Second Nat. Conference of State Parks, 1922, '23, pp. 129–147, and revised, '25). To accomplish this, most satisfactorily, such an area would require unusual natural boundaries or barriers that would serve to fence the area and barricade it from economic encroachment. The difficulty of educating the public to the appreciation of such a wilderness would be considerable, but I believe it to be one of the greatest needs today for wild life in America. It would be worth years of effort to secure such preserves or sanctuaries, where all control measures were *absolutely prohibited*. Such areas would be of priceless value, and would be so recognized, within one or two generations. Emerson Hough in proposing (Saturday Evening Post, Vol. 194, Jan. 14, 21; 1922) such a preserve of the Kaibab region north of the Colorado Canyon was a seer, whose foresight will some day be appreciated. This is perhaps the best area proposed by anyone so far, and is one which would care for not only the predators, but other wild life as well, on a large scale.

A few years ago Hahn ('13) pointed out that in competition with man the large species of wild life tended to be killed off, and the smaller to remain. This is equally true of predators. Ritchie ('20, p. 497) not only confirms this dwarfing tendency but shows that the dwarfs themselves tend to increase in number. This is similar to the fact that large animals, such as cougars, cattle, and horses, require more food and

range than the smaller ones, such as lynxes, sheep, or goats. These general principles should serve as valuable guides in the conservation of all wild life. As applied to predators it suggests that if we are to maintain, for scientific, educational, recreational or economic purposes, the large wild predators, we must expect to do so mainly in the large parks or large wild life sanctuaries, and the nearer to the wilderness—the absolutely uncontrolled wilderness—the better the chances for their preservation. We have in this a reason of considerable scientific importance for the preservation of wilderness areas, such as we do not have today, even in our National Parks.

It is a well-known fact that where their food abounds the predators will tend to concentrate. This applies of course to our domestic animals, to game preserves, to game farms, and to abundant game in the National Parks, preserves or other sanctuaries. For this reason it will require considerable study to determine just how many predators are necessary to maintain the normal balance in these almost wild preserves. Therefore the administrators of the regions, having these concentrations of game, should anticipate an increasing number of predators within and about the margins, and plans should be made for their control both within and without; but this work can be done wisely only as a result of careful scientific studies, such as we do not now have.

(*b*) National and State Forests and Game Preserves. These are areas where economic standards are generally considered paramount; and as game preserves are intended for hunting, they will favor only a limited number, mostly smaller predators. Game will thrive in such areas so that there will be a marked tendency to restrict predators in favor of game and domestic grazing animals, and particularly is this true in areas suitable to grazing and big game, but in the remote regions there will be less need of predatory control. At any time the production of fur may become a more important economic crop in forests, and then this will put new values on these animals. A certain number of the minor fur-bearers should be preserved in these forests, even if the larger ones are sacrificed on account of grazing animals and game, because many of these smaller species will materially aid in rodent control, as well as produce a valuable crop of fur.

As, however, public forests are primarily intended for the public good, the public has a right to decide how these areas should be used. Because of their huge acreage, greatly exceeding those of the National and State Parks, they have without question areas naturally suitable for the preservation of all kinds of predators, large and small, but not of course in unlimited numbers.

In the case of the predatory control, intended to preserve big game and grazing animals, one of the most important practical problems is how to limit the predators satisfactorily, and not at the same time release an over-population of rodents, which will in turn destroy forest seeds, forage, and browse, and so in turn necessitate control measures for the rodents, by poison or other means.

Serious students of eugenics are raising the question as to whether or not some of the methods of modern medicine and hygiene may not be preserving the physically unfit, to a degree that they are becoming a human menace. There is the similar possibility that to hold wild life up to the best standard a certain number of predatory animals may be very desirable, as a method of eliminating the weaklings among the game in our parks and forests. At least this may be needed for the present, until we learn more about maintaining these animals in full vigor.

POLICIES OF MANAGEMENT

Even this outline sketch of a land classification or zonation system for wild life, shows at a glance that much work, extensive surveys, and detailed field studies, will be necessary before we can have a satisfactory body of knowledge for the formulation of detailed policies for predators and other wild life. This classification is of course not new, but the need of formulating even provisional policies has not received sufficient emphasis and attention. We must now have a new type of synthetic land survey which will cover all the resources of the lands, from an economic and social point of view, and in order to plan for the future with a reasonable degree of certainty. In the past land classification has been too exclusively in the hands of geologists, timber foresters, and soil specialists, and the time has now arrived for a new approach to the problem. This will involve a new technique and a new training for the field workers, and an adequate provision should be made for the wild life resources in any such program. This would be a kind of "glorified" survey from the standpoint of applied human ecology.

I am, of course, well aware that much has been done which will serve as an excellent foundation for the preliminary plans, and there is probably stored away in naturalists' note books, and in official files, much data which will prove of the greatest value in formulating such plans and policies. But these results are not available today, and I, for one, believe that most of this work must fall to a new or younger generation

of men, who will approach the subject with a fresh and new outlook, and who will not be hampered too much by old ideas and old ideals.

Again let me emphasize the urgent need of publishing in full the great mass of scientific and economic data bearing directly upon this problem by all agencies concerned with it. No doubt all agencies are hampered by the lack of funds for publication, but the time seems to have arrived when it it has become imperative to sacrifice something else and clear up this situation. When this is done and tentative policies are formulated and published,—in order to secure the benefit of constructive criticism by all who are qualified to assist—a great advance will be made. It will require years to get these problems properly organized, and it will require constant and permanent attention on the part of many scientific men and economic zoologists, working in coöperation with other students of our social and economic problems, to keep this one steered into the right channels.

One should not conclude this discussion of policies without reference to the menace of "political" interference and to vicious propaganda which so frequently obscures conservation measures. The predators have come in for their full share. Without question this is one of the most serious menaces to American wild life. One can recognize these influences at work in almost every locality where inside information is available. In dealing with scientific studies, naturalists are seldom concerned with these influences, but as soon as they attempt to apply their science to human affairs in the form of public policies they come into direct contact with these influences. It should be clearly understood, however, that all officials, politicians, or even propaganda, are not corrupt, but unfortunately the superior, large-minded men of high ideals who take an active interest in public affairs are lamentably few, so that it is a welcome event to see them battling for constructive public measures. These men deserve better support than they usually receive. As naturalists, and as citizens, we should not take a passive attitude and allow these abuses to continue without opposition, or allow ourselves to be used as tools by unscrupulous leaders, to promote selfish and personal interests at the expense of public welfare. Until our state fish, game, forest and conservation departments, and all others concerned with these problems, are relatively "out of politics", and placed on a real merit basis, a definite goal stands before us that invites our support.

SUMMARY AND CONCLUSIONS

We may thus summarize the general situation as follows:

1. There is no fixed relative balance of nature, it is always undergoing change; the major relative balance was changed by the Indian, and much more by the European. We have passed out of the pioneer trapper-hunter stage into an agricultural one, and this is becoming more and more an industrialized culture, and we do not know how these two can be balanced. These changes impose new relative balances upon all wild life, including the predators, and thus this unending process of adjustment to change continues.

2. The predators are of great scientific, educational, recreational and economic value to society, and they should be preserved; and the practical problem, is *how* and *where* to do so.

3. In order to determine the location of relatively stable places for their preservation, to advise methods of managing these areas, and to estimate their probable future use, we need a new kind of a land survey, covering its economic and social uses.

4. Present probabilities indicate that the classification of lands into urban, agricultural, and non-agricultural, is fairly reliable, and may serve as a basis for wild life policies.

5. Upon urban lands, the probabilities are that predators will be perserved only in small numbers, and as small-sized species.

6. Upon agricultural lands, their numbers and size will probably decline directly with intensive cultivation, and therefore only the remote, isolated, or poor lands will permit their survival in numbers. These remote and isolated lands are, however, suitable for the economic production of fur, and probably for the utilization of predators for rodent control. The inferior agricultural lands are suitable areas for public wild life preserves, game preserves, sanctuaries, and wildernesses, and here without question constructive measures should be taken to preserve these animals.

The forest and park lands, being non-agricultural, are devoted to two purposes,—the forests being primarily economic, and the parks primarily social. The forests and game preserves have much in common, as grazing and game will require predatory control of some kind. These areas should permit the preservation of large predators to a limited degree, and many of the smaller kinds. These are lands very suitable for public preserves for wild life, as mentioned above for the poorer agricultural lands. The park lands should be among the best areas for the preserva-

tion of all the predators, as here the large and small species, in relatively large numbers, should be preserved because of their social value. The relatively unstable lands are mainly those which are transitional in character, or in location. These are marginal urban land, the poorer tilled land, and the richer-soiled forest lands, because under economic pressure their status changes most quickly, while the extreme conditions of inaccessibility and poverty of soil tend toward stability, and are more likely to retain a permanent policy. A supreme need is for large, wholly wilderness areas with natural barriers, not only for the preservation of the large predators, but for other wild life needing similar conditions.

7. The preservation of the predators should be recognized as an economic and a social problem and the probabilities are that, viewed from the broadest possible standpoint of the public, there can be little doubt that we should willingly pay the necessary price in lands, funds, and public interest to maintain them for future generations.

8. And, finally, there should be a constant effort on the part of naturalists to keep the wild life problem as free as possible from all corrupting political affiliations and cheap propaganda, as this is one of the greatest menaces to wild life today.

It is not enough to present a policy in the form of a brief sketch, such as this; it must be worked out in detail so as to be reasonably applicable for a period of years, during which every effort should be made to study and improve it. In conclusion, let me quote with approval the following statement of the Russells:

> The chief enemy is always premature synthesis, whether based on traditional superstition, or on outworn instinct, or on incomplete scientific knowledge. To point to this ruthlessly wherever it is perceived, regardless of possible inconsistencies or disappointed ideals, must be the task of disinterested inquirers in any period of history.

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THE STELLER SEA LION ROOKERY ON AÑO NUEVO ISLAND, CALIFORNIA, IN 1924

BY BARTON WARREN EVERMANN AND G. DALLAS HANNA

[*Plates 8–10*]

On June 27 and 28, 1920, in company with Mr. Joseph Mailliard, curator of birds and mammals in the California Academy of Sciences, the senior writer visited the Steller sea lion rookery on Año Nuevo Island off the California coast some 60 miles below San Francisco. An account of the trip with notes on the rookery as then observed was published in the JOURNAL OF MAMMALOGY for February, 1921, pp. 16–19.

On June 22, 1924, the present writers, accompanied by Mr. M. L. Lombardi, visited the rookery where we spent the day making observations and taking photographs, and the junior writer again visited the island a week later, June 29, when the observations were repeated and more photographs were taken.

The rookery has not changed much since 1920. On the first rock nearest the fog-signal house there were 10 old bulls. On the next rock to the right there were about 300, among them many very large old bulls and several pups. On practically all the other rocks all the available space was occupied, and there were always a good many in

the water. Pups were common everywhere, some quite large, others just born or only a day or two old.

Our census of the animals by actual count, verified and corrected by enlarged photographs on which the seals could be quite accurately tallied, gives a total of about 2000 adult males, adult females and young of the year.

We are of the opinion that this is about the maximum number that these rocks can accommodate. The only important area now unoccupied that might be used is certain narrow strips nearer the light house. There is a considerable area of grass-covered ground, but evidently such area is not well suited to their needs because of the distance from the water line. It is not at all likely that the sea lions will ever occupy it; the overflow probably prefers going to other rocky islets along the coast not yet fully occupied.

It is therefore probably safe to say that about 2000 to 2500 is the maximum size the Año Nuevo rookery can attain.

Attempts made to count the animals in the herd from the land surface resulted in figures which were, in part, estimates because vantage points from which all can be seen are wanting. But from the top of the light some excellent photographs were taken with a long focus lens and on the enlargements made from the negatives it was possible to tally off the animals one by one at leisure. Practically the entire herd was thus represented; the few occupied areas which may have lain in concealed situations were certainly only a small proportion of the total.

The total number of adult males and females visible on the photographs was 954. Those uncounted because of obscure positions in which they lay are not believed to number more than 150.

A considerable number of outlying idle bulls was in evidence so that the average harem for the herd probably did not exceed 10 although individual groups of 15 and 18 were common. If the average size of the harems be taken as 10 there must have been 849 breeding cows, each of which may be assumed to be the mother of a pup. Thus the numerical strength of the breeding herd, estimated on the basis of animals photographed, is as follows: bulls, 95; cows 849; pups, 849; total 1803. Those concealed and in the water would undoubtedly raise the total to about 2000.

An entirely satisfactory method of estimating immature males and females is not available, a difficulty which always besets the taker of a census of marine mammals. Undoubtedly they were elsewhere than about Año Nuevo on the date of our visit. Mr. Becker, the keeper of

the light, stated that some sea lions are present on the island throughout the year, so it is possible that the young males and females haul out there after the breeding season is over.

The method of making the census from photographs is especially to be recommended to those who may have similar opportunities in the future. Our first experience with it was had in 1922 when a practically accurate count of elephant seals hauled on Guadalupe Island was made in that way. The difficulties on the ground of counting such groups of objects, close together, indiscriminately arranged and moving about are almost insurmountable. But with the photograph one can tally each one off, marking it at the time with white ink to prevent duplication. This method is believed to be more nearly accurate than any field count which can be made in localities where suitable elevations are available from which the photographs may be taken.

Albinism was noted among the pups in one instance and the light keeper reported another. The one seen was not many days old because a portion of the umbilical cord was still attached. Although it took to a small pool of water upon close approach it could do no more in way of swimming than keep itself afloat and exert desperate efforts to remain on solid bottom. This animal was almost pure white with pink flippers and eyelids. The iris was also pinkish and it appeared to have considerable difficulty in seeing objects distinctly. Mr. Becker, the light keeper then in charge of the reservation, who had been on the island for 15 years, reported that he had noted albinism in but one instance previous to 1924. Undoubtedly it occurs very rarely in this species and as with fur seals defects in vision probably almost always prevent the animals reaching maturity.

The date of the breeding season on this rookery would seem to be exceptionally late. On St. Paul Island, Bering Sea, the northernmost rookery of the species, the height of the breeding season is about July 1 each year. In other words, in a range of approximately 2000 miles from north to south there is no variation in habits in this respect. Two conclusions may be drawn from this, either one or both of which may be true. The date of breeding season in the north is apparently established because of climatic conditions. The species may be such a late migrant to the northern rookeries that sufficient time has not elapsed for a change of date of breeding season. Or possibly there is sufficient interchange of animals among the rookeries throughout the range to cause uniformity in this respect.

The rookery on Año Nuevo is apparently unaffected in the slightest

A surf-washed rock in the foreground used only as a hauling out or resting place. Dense rookery area in the background.

Section of a thinly populated rookery in the foreground, and denser areas in the back.

STELLER SEA LION
Photos by Hanna

A very vigorous adult bull. Note the exceedingly powerful neck and forequarters.

An adult bull, showing the massive neck and forequarters and comparatively light hindquarters.

STELLER SEA LION
Photos by Hanna

An albino Steller Sea Lion pup

Two very young pups washed from the rookery to a small boulder beach not over 50 yards away, but, judging from their emaciated condition, deserted by their mothers.

STELLER SEA LION
Photos by Hanna

degree by presence of the light house and fog-signaling apparatus. The tameness of the animals also shows that they are accustomed to the close proximity of man. No difficulty is experienced in approaching within a few rods of the herd without causing disturbance. On the contrary on St. Paul Island males and females alike stampede into the sea upon the first sight of a man and even his odor drifted on favorable wind a quarter of a mile will cause them all to desert their young in a wild scramble. But in the water and on the rookery no apparent differences in habits of the animals between the two rookeries were noted. It has been observed on both that when the cow returns to the pup she spends considerable time and effort searching for a certain one, presumably her own. In this respect the habits are apparently the same as with the fur seals and should be given proper consideration in any legislation which may be proposed in the future to exploit the species.

As to making commercial use of surplus males of Año Nuevo herd and others on the western coast we believe that herein lies a possibility for a certain amount of profitable activity. The species is polygamous so that approximately 10 per cent of the males are in excess of breeding requirements, and this portion might well be exploited. It is expected that measures will be advocated in the next session of the California legislature whereby the Fish and Game Commission of that state will be enpowered to carry on the necessary preliminary experimental investigations to determine the commercial possibilities of the species.

It is interesting to watch the life of the rookery. Some of the sea lions lying still as if asleep; others swaying their heads slowly back and forth or merely looking about in a stolid sort of way; others moving about more or less, walking or jumping, sometimes slowly, sometimes rapidly (for a sea lion); still others sparring as if fighting, with now and then a real fight; often one or more moving to the edge of the rock and taking a header into the water, while an equal number may be seen climbing back upon the rocks; a number always swimming about, mostly close to the rocks but some times quite a distance away; meanwhile a more or less low dull roar all the time on all sides, perhaps the most characteristic, ever-present feature of the rookery.

California Academy of Sciences, San Francisco.

WALRUS PROTECTION IN ALASKA

By Joseph F. Bernard

As the principle of conservation of various species of our fast disappearing animal life spreads in all countries, we see reservations everywhere for the protection of land mammals, in whose welfare public interest has been aroused. But with the notable exception of the Pribilof Islands in Alaska, there are few reservations in the world for our sea mammals, which are disappearing with the same rapidity as the land mammals. The killer whale is an exception owing to the fact that it has no commercial value.

Thirty or forty years ago in various places along the Alaskan coast walruses were known to haul in countless numbers. But when the white settlers came and saw that there was commercial value in the ivory, the extinction of the Alaskan walrus life began. Today although the walrus herds pass along the coast of Alaska on their route of migration northward, seldom do even a few walrus come to shore and when they do, they are soon frightened away by the native hunters.

The result is that the walrus stay off shore, and the natives go out and hunt them on the ice. Although to the native the meat of the walrus has the greatest economic value, it is seldom that the Eskimos can bring anything but the ivory tusks ashore. Thus they sacrifice tons of good meat, highly prized by them, because it can not be landed.

During the summer of 1923, while cruising along the Alaskan coast north of Point Hope to Wainright Inlet near Point Barrow, I examined a stretch of coast of over 200 miles from Cape Lisburne north. A westerly wind had washed ashore on that one part of the coast over a thousand bodies of walrus which had been killed among the ice floes by the Eskimos. One-third of the walrus bodies still had the ivory tusks, showing that the walrus had been shot and had slipped off the ice and sunk before the natives had reached them. These animals were a total loss as the meat was spoiled when the bodies came ashore. If a thousand walrus bodies reached shore, one may imagine how many thousand more were carried by the ice and current northward into the Arctic Ocean beyond Point Barrow.

Not more than ten or twelve years ago this same situation existed at Ingshong, Siberia.[1] By wise methods in killing the walrus after they

[1] Local Walrus Protection in Northeast Siberia. By Joseph F. Bernard. Journal of Mammalogy, vol. 4, November, 1923, pp. 224-227.

had hauled on the beach, the Chukchees induced them to return to land for two months each year. It seems that in the methods employed by the uncivilized natives of Siberia we might find a lesson for the preservation of the walrus for Alaska.

There is a strip of broken beach about 25 miles long, extending from the entrance of Maryatt Inlet to Cape Lisburne. This strip of coast is a place where formerly the walrus hauled in large numbers, and it is the only place on the coast of Alaska where today a walrus occasionally lands. But the animals are never allowed to lie there any length of time, as the natives patrol the coast on the chance of finding an occasional walrus. No walrus, landing there as things are now, has much of a chance of going back to sea unmolested. That particular walrus is not likely to return to this spot.

If this beach could be set aside by governmental action as a walrus preserve, it is a certainty that a herd of walrus would again eventually appear on this beach, for if the few animals that now land were permitted to spend a season there, to go and come in peace, they would gather a large herd which would increase rapidly from year to year.

This whole coast line is an ideal place for such a reservation, as it is a high cliff having a steep beach at its foot from 50 to 100 yards wide. The sea is deep at this point and large numbers of walrus pass in their migrations spring and fall. The sea grounds off this beach are also ideal feeding grounds for walrus. This can be told from the large numbers of clam shells washed ashore. The clam is the favorite food of the walrus.

This stretch of coast line is not inhabited. The nearest natives are at Point Hope, 10 miles south. The Alaskan Eskimos are very law-abiding. Moreover they already know what the Chukchees have succeeded in doing in Siberia in attracting the walrus back to land by proper treatment. If it were explained to the Alaskan Eskimos that after two or three years of protection at this spot, the large herd would be likely to return, they would cheerfully observe the law. This protection of the walrus on shore would not interfere with the hunting at Point Hope and other places where natives are settled.

If such a reservation should be established and regulations made whereby the natives were allowed an allotment of walrus to be killed on certain days, as is the custom at Ingshong, Siberia, there would be no waste as now exists under the present custom of killing out on the ice.

It seems impossible to enforce the present law, that walrus are to be

killed only for meat. The natives kill for the ivory or not at all. No matter how much they need the meat, they can only bring small pieces of it ashore. With the coöperation of the Eskimos and the Bureau of Education, it would be easy to protect the walrus on such a reservation.

Loyola College, Montreal, Canada.

NOTES UPON THE NUMERICAL STATUS OF RODENT POPULATIONS IN PARTS OF CALIFORNIA[1]

By Joseph Mailliard

An article entitled "Periodic Fluctuations in the Numbers of Small Mammals," by Mr. A. Brazier Howell, in the Journal of Mammalogy, vol. 4, no. 3, 1923, attracted my attention at the time of its publication, and it has since occurred to me that in view of the bearing they have on the matter of fluctuation in numbers of rodent population, my recent experiences in the field may be of interest to others, and possibly of some value.

Since seriously taking up the study of mammalogy, some five years ago, I have met with fluctuations in size of the rodent population in many localities. In the majority of cases, it was the lowest ebb that was experienced, although the reverse was met with on some occasions. Probably my experiences of the year 1923 illustrate as well as any what may happen in the way of variation in numbers of *Microtus*, *Peromyscus*, etc.

My field work for 1923 commenced at Burney, Shasta County, California, altitude about 3000 feet, on April 27. With its varied character of country, its meadows watered by willow-bordered streams, its tracts of sage and other brush, its forest land and its open fields, Burney appeared to be an ideal locality in which to find numbers of the small mammals inhabiting the Sierran Transition Zone. During the eight days passed there, however, *Peromyscus maniculatus gambelii* was the only small rodent that showed signs of being present in any appreciable number, and even of this species the representation was not at all large. Two successive nights' trapping in any limited area cleaned up all the *Peromyscus* within reach of the traps, and no other rodents appeared in them.

[1] Contribution from the California Academy of Sciences.

In the meadows close to Burney were some old signs of *Microtus*, but none that was fresh. In a meadow 7 miles away, however, some runways made by individuals of this genus were found to be in use. In the latter spot, with about 50 traps set for two successive nights, some of them in the edge of the woods, but most in the runways in the grass of the meadow, 5 *Sorex*, 2 *Microtus*, and 1 *Peromyscus* comprised the total catch.

In a rather brushy corner of a dry, open field near Burney, 1 *Dipodomys* and 1 *Perognathus* were found in the traps one morning, but that was the only occasion upon which *Dipodomys* was taken, and one of the two occasions upon which *Perognathus* was secured during the two months covered by the field trip. At Buck Creek Forest Service Station, Modoc County, near Goose Lake, three specimens of *Zapus* were secured on the night of May 18, the only time that this genus showed up in our traps. At no other station during the field work in Lassen and Modoc counties, from April 27 to June 24, with the exception of a few *Thomomys* in Jess Valley and Eagle Lake, was any small rodent other than *Peromyscus m. gambelii* found in our traps, although anywhere from three to ten days were passed at each of the six stations where collecting was carried on, with from a dozen or so up to 75 traps set each night so long as there was any prospect of a return for the work involved.

All through northeastern California are meadows of various sizes, irrigated by water led from the mountain streams, in which natural hay is raised for the winter feeding of cattle. The proprietors of all these meadows we visited during our field work told us the same story of the abundance of *Microtus* in their hay fields, and unanimously complained of the trouble caused by this rodent during the haying season, the nests frequently clogging the sickles of the mowing machines and the mice themselves being found under every haycock. In fact, we were told that there would be no trouble in finding any number of meadow mice by trapping for them where old haystacks had stood, and at earth dams in the irrigating ditches. But that spring we found absolutely no fresh signs in either Modoc or Lassen counties, and the only specimens secured on the trip were the two taken near Burney, Shasta County. Later, during the haying season, Ranger Lawrence Smith, of the Buck Creek Station, stated that there had been no meadow mice seen that summer. At Eagle Lake, Lassen County, our experience was the same: the same stories of usual abundance of meadow mice and the same failure to find them.

On the way back to San Francisco, however, while passing through the summer resort called Mineral, in Tehama County, I was so much attracted by the appearance of a roadside meadow that I jumped out of the car and examined it, finding perfectly fresh signs of meadow mice and evidence of a fairly large population in the abundance of freshly cut bits of grass stems in the runways. This meadow was at an elevation of about 5000 feet, as were most of the other meadows examined by us for *Microtus*, but it was on the *west* side of the Sierras, and the evidently large number of meadow mice occupying it showed that the factor, whatever it was, causing the decrease in rodent population on the *east* side, either had not yet come into play on the west side, or had ceased to operate sufficiently long before to allow of a healthy recuperation from its effects.

During the time of this dearth of rodent life in northeastern California, there was, on the other hand, in parts of the territory just north of San Francisco Bay, at least, an unusual invasion of *Microtus*, together with a great increase in the local population of *Neotoma*. People in the suburban settlements of this district complained of depredations among their flower beds, of plants being dragged perpendicularly into the ground before their very eyes, of begonias being cut into bits during the night, and of other troubles of similar nature. Investigation proved that the marauders were members of colonies of the California meadow mouse (*Microtus californicus californicus*), established in places where they had never before attracted attention. Later in the year, I found this rodent quite numerous on the north side of Point Reyes, Marin County, near the head of Tomales Bay, where it was found both in the salt marshes and up in the hills.

During the fall field work of 1923, carried on principally in September, *Microtus* were found to be numerous on the west side of the Sierras in Butte County and also on the east side of the range at Bogard Ranger Station in western Lassen County. In the latter place, especially, they were present in such numbers that they had not only honeycombed the banks of the little mountain stream flowing through the wooded meadow, but also had spread their burrows out into the sagebrush plain even quite a number of yards away from the streamlet that a little farther on disappeared in the sand and lava of the plain. All the specimens secured at this time proved to be of the form called the Yosemite meadow mouse (*Microtus montanus yosemite* Grinnell).

In the spring of 1924, some of the ground covered in the previous year was revisited, notably at the Buck Creek Forest Service Station.

At this place, careful examination of the meadows failed to reveal any sign of *Microtus* activity, and Ranger Smith said that he had noted no individuals of this genus since our visit of the year before.

At Eagleville, Modoc County, California, 17 miles south of Cedarville, in the vicinity of which we had failed to find any *Microtus* in 1923, and on the same continuous line of meadow land, there were, in 1924, limited signs of this rodent around one stack of last year's hay, and several specimens were taken there. Examination of other old hay stacks in the neighborhood, however, did not disclose any further signs, but quite a lot were discovered at the south end of Middle Lake in a nearly dry patch of tules surrounding what is usually a laguna of some size. The winter of 1923–1924 and the following spring were the driest on record since the settlement of California by Americans, and this laguna was but a shallow, rapidly diminishing pond. It appeared as if the *Microtus* had left the meadows, probably before the spring irrigation had commenced, and made a last stand beside this small, fast receding body of water.

Another experience with *Microtus* fell to my lot in September, 1921, when I went to Capetown, Humboldt County, to procure some topotypes of *Microtus californicus constrictus*, the Cape Mendocino meadow mouse. Mr. Joseph Dixon, of the Museum of Vertebrate Zoology, Berkeley, California, had told me of the great numbers of meadow mice present there at the time of his visit, and of how he had to go over his *unbaited* traps several times a day to remove the mice they contained. At the time of *my* visit, two nights of trapping in the identical spot resulted in the capture of only *one individual* of the sought-for species!

California Academy of Sciences, San Francisco.

BREEDING AND DEVELOPMENT OF THE COLUMBIAN GROUND SQUIRREL[1]

By William T. Shaw

[*Plates 11–14*]

It has long been well known that it is difficult to induce wild animals to breed in captivity. This difficulty seems general and has been referred to by Darwin, in his "Origin of Species by Natural Selection." chapter 1, page 10: "Many facts clearly show how eminently susceptible the reproductive system is to very slight changes in surrounding conditions. Nothing is more easy than to tame an animal, and few things more difficult than to get it to breed freely under confinement." In the extensive and long-continued investigations recorded in this paper only four Columbian ground squirrels (*Citellus columbianus*) were successfully bred, and the data accompanying the rearing of their broods secured. The equipment necessary for the securing of such data must of necessity be of such nature as to give the animals under observation the utmost freedom. In securing the data here recorded very ample yards were enclosed and in them were the original dens of the wild squirrels to be studied. So ample and free-ranging were these yards, that the animals were practically at liberty to come and go as they desired; yet at all times they were under the absolute control of the investigator. Into these yards squirrels which were carefully branded, weighed, and recorded were turned, segregated according to sex; and here they lived a life of comparative freedom. In fact, they were so nearly under normal conditions that they never became very tame, but always darted into the holes as wild squirrels do when approached. Shortly after coming from hibernation they showed signs of a desire to breed, thus enabling us to take the first steps in determining the gestation period.

Branding system. The convenience of a branding system was at once apparent. It became necessary to recognize with the binoculars, instantly, definitely, and without disturbance, from the quiet of the cabins, any squirrel running at liberty in the yards. This necessity led to the development of a double system of brands known as temporary and permanent. The temporary brand was made by singeing

[1]Published with the approval of the Director of the Washington Experiment Station as Scientific Paper no. 120, College of Agriculture and Experiment Station, Pullman, Washington.

off the gray hair tips, thus making a conspicuous black spot by exposing the dark base of the pelage. The marks were applied to certain regions, as right or left shoulder or hip, and had to be renewed each year, owing to the moult.

The permanent brands were made by docking the tail, excising a toe, or punching a small hole in the ear, and were used in various combinations. These were employed to designate with certainty given animals, recorded, for example, as "Female 20; outer toe, right hind foot lacking." Further records were kept by taking the customary measurements for small mammals, and by taking foot impressions by smearing the bottom of the foot with black paint and making the impress upon paper.

Rutting. This activity coincides with that of the squirrels in the fields. As the rutting season advanced they developed unmistakable symptoms of restlessness, frequenting the dividing fence. When it was felt certain that the period of rutting had come, the female was allowed to pass through the lift-gate into the yard of the male.

Segregation of sexes in yards. After a few hours, when rutting had taken place, it was necessary to separate the sexes in order that the length of the gestation period might be accurately determined. At first the males were shot or taken in a box trap operated with a string from the cabin, or in the traps in which the "figure four" had been placed. Note was now taken of the actual time during which the sexes were together, and this taken as the starting point of the gestation period. Usually the female was allowed to remain in the yard formerly occupied by the males, for a day or two at least, before being returned to her own yard, where she was permitted to remain for a period of about sixteen or eighteen days before being trapped for one of the brood yards, in which she could be observed closely at the time of parturition. Later investigation showed that it was much simpler and equally effective to trap the female with a box trap and transfer her, trap and all, into the yard with the male, and to return her in the same way within three or four hours after having been bred. In order that uninterrupted observation might be carried on with more than one female at the same time it was found most convenient to place the females in Yard 1 and the males in adjoining Yards 2 and 7.

Recurrent periods of menstruation. If the female was not bred, the rutting period lasted two or three days before it passed. It not infrequently happened that the opportunities for breeding were lost, owing to some unavoidable disturbance or delay. It soon became

apparent that the squirrel would return to the condition of menstruation in about 14 or 15 days. One female appeared to be in menstruation on April 1, 15, and 29. If not bred, this period may continue to return for some time, even as late as May 2, six weeks later than the first wild squirrels were observed mating.

Female during the period of pregnancy. These squirrels appeared to be affected in an interesting way for a few days before and after the time of parturition. After being transferred to a brood yard, Female 20 was very restless and tried to dig out. About the 20th of April she ceased this almost entirely; eating very little for two days previous to parturition, gradually picking up on the 28th, shortly after producing young.

Length of gestation period. In these experiments only four squirrels were successfully bred, and the data accompanying the rearing of their broods secured.

The determining of the gestation period will best be shown by the following records of the breeding of a female mated between 12:22 P.M., April 17, 1911, and 12:36 P.M., April 18. On April 24, 4:30 P.M. she was captured from Yard 2, and returned to Yard 1. Here she remained until May 3, when she was captured and placed in an observation brood yard. Hourly observations were made during the day and most of the night. These were kept up through May 8, 9, 11 and 12. At 10:45 P.M., May 11, no young were found. At 5:05, May 12, there were seven young in the nest. The length of her gestation period lay between 12:22 P.M., April 17 and 12:36 P.M., April 18, and 10:45 P.M., May 11, and 5:05 A.M., May 12, or a period of 24 days.

In like manner Female 1 gave a gestation period of 23 days, Female 20 a gestation period of 24 days and Female 43 also a period of 24 days. It is almost certain that in the case of Female 1, where the time range is so wide, that she was bred on April 5, 1911, instead of the 6th, which would make her gestation period also 24 days.

Post-breeding season. The post-breeding period follows without any marked or sudden change in activities. Its approach is first indicated by the condition of the testicles, for during the rutting season, even at the time of their coming from hibernation, these organs are highly congested and of maximum size, and scrotal. Later, however, they diminish greatly and even become abdominal. On May 10, it was noticed that none of the females in Yard 1 had shown signs of being in menstruation since May 4. Females were allowed with the males on the 16th of May, but failed to breed after this date.

Early development. In studying this part of the life history one is struck with the rapidity of the growth of the young. Though very imperfect at the time of birth they begin at once to develop and at the end of thirty days are ready to shift for themselves.

Embryo. In anticipation of the gestation period, the squirrels appearing from hibernation still have an abundance of fat, which undoubtedly helps those of both sexes through an adverse period of scarcity of food and is of vital use to the pregnant females. In females dissected it was observed that, as the embryos advanced in development, there was a corresponding reduction in the amount of fat carried over from hibernation. In 1911 the rutting season began on March 13, and on April 6 a very mature adult was taken bearing six embryos completely formed. They were 22 mm. long, from the cervical to the sacral bend.

Appearance and weight of young at time of birth. At birth, young squirrels are naked, flesh colored or slightly pinkish, blind, toothless, and apparently have the external auditory meatus closed.

The following table shows the numbers and weights at birth of five litters born in captivity.

Weight of young at time of birth

NUMBER OF LITTER	NUMBER OF YOUNG IN LITTER	AGE	WEIGHT OF LITTER	WEIGHT OF ONE FEMALE	WEIGHT OF ONE MALE
		hours	*grams*	*grams*	*grams*
1	5	21	38	7	8
2	7	9	50		
3	4	5	45		
4	5		41	9	9
6	2	18	24		

The weight of the litter does not seem to bear direct relation to the number of individuals comprising it. The smallest litter, consisting of two squirrels, weighed 24 grams, or 12 grams each; while one litter of 5 weighed 38 grams, or 7⅗ grams each. Two litters of Townsend squirrels contained 11 and 8 squirrels respectively and weighed 31 grams each litter.

Growth. The development of the squirrels is very rapid, as shown by the following table.

Daily weights of litters

AGE	LITTER 1 (5 YOUNG)—WEIGHT	LITTER 2 (7 YOUNG)—WEIGHT	LITTER 3 (4 YOUNG)—WEIGHT	LITTER 4 (5 YOUNG)—WEIGHT
	grams	*grams*	*grams*	*grams*
Birth	38	50	45	41
14 days	151	167	184	126
28 days			382	253

That the growth of the young squirrels considered in this table was fairly normal is probable, for they were tended carefully. Each mother had a large yard in which to run, and was supplied regularly every morning with an abundance of freshly dug clover and bluegrass sod, supplemented with carrots and apples.

Behavior of young sleeping squirrels in the nest. To observe a nest of young sleeping squirrels is most interesting. Some are dozing with eyes shut; others are wide awake, and rooting about among and under their fellows. They sleep well, yet a slight noise disturbs them, but they soon doze off again, with eyes tightly shut. While asleep they show a peculiar spasmodic twitching, or characteristic nervous jerking, even at 4 days old. This peculiarity was noticed in the brood cabin where frequent daily observations were made during the first days of their life.

Nursing. The nursing period normally lasts about 30 days and probably continues into the period when the young begin to secure food from other sources. One litter was observed still nursing at 35 days old though they were seen nibbling at bits of grass when 25 days old, using their front paws skilfully.

Another litter was observed taking solid food, including grass, apples, carrots, and dandelions at 30 days old; and still another litter at 35 days old. It is probable that the period of weaning in the yards, where the above observations were made, was somewhat delayed, because the mother and the young were unavoidably kept together and not allowed to scatter as in the wild condition.

Observations here make it appear that the young may be supplied food from another source than their mother's milk. About weaning time, young squirrels were observed on their backs in the attitude of nursing but with their mouths applied at right angles to that of the mother with the lips vibrating rapidly as in sucking. The paws of the young were placed on the side of the mother's head or even over her eye. It would seem that they get something from the mother in this

way as they are very persistent in this action. Similar observations were made on a brood of *Citellus townsendi*. Young squirrels deprived of their mother have been observed trying to secure something from each other in a similar way. This observation suggests the feeding of the young by regurgitation.

One female in the brood cabin, not satisfied with the conditions of temperature and exposure, as provided in the box nest, made a burrow in the earth in the yard and after a day or so transferred the nest material and young to the more natural home. Another transferred the nest material and young in this manner when the young were 11 days old.

Development of voice. The voice is present at the time of birth, but is undeveloped. The note given by young 4 hours old resembles that of very tiny kittens and was heard in the quiet of the cabin almost any time of the day. When only 14 days old, the eyes still closed, the young gave the call note of the adult, rather clearly and quite distinctly, when removed from the nest. At 34 days old they were standing on their hind legs giving clearly the call note of the adult. At four weeks old, they uttered the vibrating lip or tooth-grinding sound when excited.

Development of hearing. The sense of hearing is developed in keeping with that of the voice. It is developed coördinately with the voice and somewhat in advance of sight. At first the external auditory meatus seems almost closed and the external ear, never very large, is quite rudimentary. The sense of hearing was acute in one litter at 19 days, for they would jump at the click of the camera shutter. When 29 days old they were out of the den and responding very quickly to the call of the adult. At 34 days old, the sense of hearing was very acutely developed.

Development of sight. Born with the eyes shut and living as they do for the first three weeks of their life in total darkness, they are slow in developing the sense of sight. For a day or two before the eyes begin to open they develop a constant twitching of the lids, repeated every few seconds, which eventually result in their opening. Close observations were made on five litters of developing squirrels. It was noted that the twitching which resulted in the opening of the eyes began at the 17th or 18th day; that the eyes began to open at the 19th or 20th day (fig. 5); that their eyes were all open by the 21st to 23rd days. It is also remarkable that even before the eyes are open the young are very nervous and pugnacious and assume defensive attitudes when molested.

At best the sight of the squirrels, though very keen, seems intended for daytime only, for they have very poor use of it in the dark. They must rely on some other sense for directing them in the dark burrow. It is remarkable, as noted in the cabin, that the young begin to crawl out of the nest at 17 days and are able to find their way back into the hole leading to the nest when put out away from it, though their eyes are still closed.

Dentition. The very young squirrels are quite toothless. Two litters examined showed the incisors appearing at 14 days and clearly through at 19 days.

Development of hair and color changes. At the time of birth the young are practically destitute of hair (fig. 1). Its growth is very soon noticed and it proceeds steadily until at the time of leaving the dens the young are quite uniformly clothed in a pelage resembling that of the adult (fig. 6).

From day to day this development, as observed in four litters, was as follows: At two days old the young begin to turn dark, developing hair; at 3 days old vibrissæ are showing rather markedly; at 5 days old the young are turning quite black on the back and sides, remaining light on the legs and undersides; at 6 days old a faint tinge of red appears about the nose; at 7 days old short and silky hairs appear over the body generally; at 9 days old the nose is sandy and dark spots begin to show faintly on the back; at 10 days old, the dark spots are clearly shown on the back (fig. 3); at 13 days old the color spots are showing very clearly and neatly (fig. 4); and at 18 days the young are wearing the strong, light color of the adults. At 8 weeks old (fig. 7) the young squirrels are shedding their first coats and by the eleventh week have completed their moult (fig. 8).

Activities of the young squirrels. The early development of activity among young squirrels is surprising. At four days old they show much undirected wriggling activity; at 17 days old they begin to crawl out of the nest and show strength in their front legs; at 20 days old they are very active and crawl out all over the nest; and at 28 days they are able to dig.

Emerging from the den, and migration. Observations made in the yards indicate that the young squirrels probably begin to move about in the den two or three days before showing themselves. Three litters studied there first emerged from their dens at 21, 24 and 29 days, respectively. Within a week, the young were seen digging out old burrows, preparatory to independent activity.

FIG. 1. Twelve hours old

FIG. 2. Seven days old. They have lost their pinkish color and have become quite dark above, due to developing hair.

FIG. 3. At ten days they have become clothed with fine silky hair defining faintly the future spots so characteristic of the species.

COLUMBIAN GROUND SQUIRREL

(Shaw: Columbian Ground Squirrel)

FIG. 4. Fourteen days old. Though seemingly still very imperfect, they are developing the senses rapidly, and at this age may utter the call note of the adult.

FIG. 5. Twenty days old

FIG. 6. Twenty-nine days old. Shortly after leaving the brood nest they may be found congregated about the entrance of their home. Their development is truly very rapid.

COLUMBIAN GROUND SQUIRREL

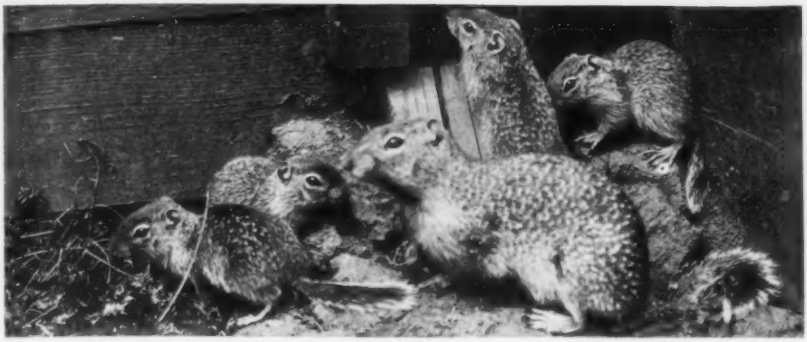

FIG. 7. Eight weeks old. These four smaller squirrels are here shown with their mother. It is not normal for them to be banded as a family at this age.

FIG. 8. Eleven weeks old. The young squirrels are now becoming fat in anticipation of the long period of æstivation and hibernation which they are soon to enter.

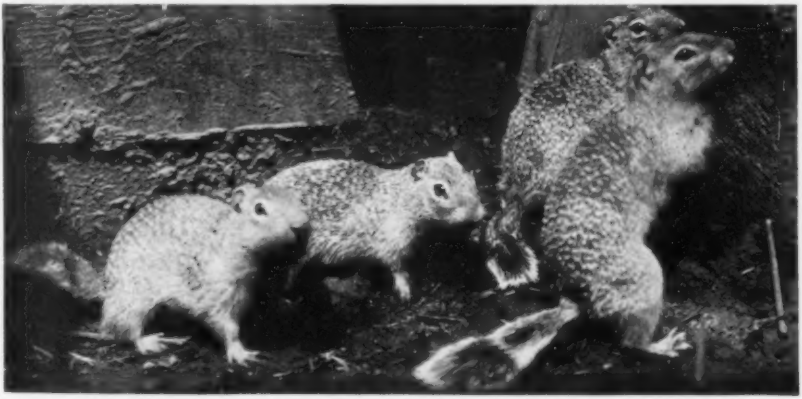

FIG. 9. One year old. These four immature squirrels have now returned from their first long hibernation. They are still under weight, but are now ready to breed for the first time.

COLUMBIAN GROUND SQUIRREL

(Shaw: Columbian Ground Squirrel)

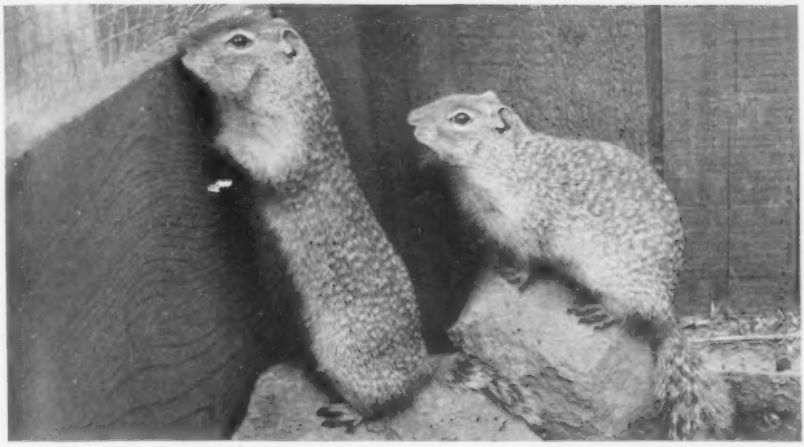

FIG. 10. Two years old. At this age they have become quite mature, have bred once, and passed their second hibernation.

FIG. 11. Three years old. At this age the squirrel is mature and handsome.

FIG. 12. Four years old. This squirrel is one of the five young squirrels shown in figure 1. That its identity is certain is due to the permanent brands which it wears, as described in the text.

The first appearance of squirrels from hibernation and of the young from the dens for three consecutive years is as follows:

YEAR	FIRST APPEARANCE OF SQUIRRELS	FIRST APPEARANCE OF YOUNG	YOUNG SCATTERED
1911	March 8	May 9	
1912	March 1	May 4	May 17
1913	February 21	May 10	

Maturity and age. Our investigations showed that the Columbian ground squirrel does not complete its growth until the second season. Of the squirrels studied, 5 averaged 105 grams at 7 weeks old, and 4 averaged 118 grams at 8 weeks old. A male and two females 11 weeks old weighed 149, 187, and 259 grams, respectively. Subsequently yearly weights were kept of one female with the following result: one year old, 253 grams (fig. 9); 2 years old, 340 grams (fig. 10); 3 years old, 331 grams (fig. 11); 4 years old, 305 grams (fig. 12).

It was further found that 6 squirrels averaged 245 grams at one year old, and that two squirrels averaged 336 grams at two years old. Between two and three years of age the weights are about the same.

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ON SOME CHARACTERS OF TAXONOMIC VALUE APPERTAINING TO THE EGG AND THE OVARY OF RABBITS[1]

By Carl G. Hartman

There seems to be general agreement among mammalogists with Gidley's suggestion (1912) that the Lagomorpha (rabbits and hares) be given the rank of order coördinate with their near relatives, the Rodentia. The distinctive characters selected by Gidley concern the dentition and the skeleton, hard parts generally employed in taxonomy because of their relative ease of preservation. The use of soft parts would, however, be just as valid for diagnostic purposes. For bones and teeth are directly dependent upon connective and epithelial tissues from which they are derived and are, indeed, indirectly conditioned in their type of development by many morphogenetic factors, such as internal secretions of the thyroid, parathyroid, hypophysis and gonads. And all these are finally under the control of hereditary factors or genes. It is the purpose of this paper to call the attention of taxonomists to several additional characters more or less distinctive of the Lagomorpha, as indicated in the title.

THE OVARY

The rabbit ovary has long been the classical object for the demonstration of interstitial cells, those large cells with round nuclei and certain eosinophilic and lipoid inclusions in the swollen cytoplasm. In the rabbit the stroma is largely made up of such interstitial tissue, so that Ancel and Bouin (1903) speak of the "glande interstitielle" in this animal. I have seen the same development of the interstitial organ in several wild species of rabbits as well as the domestic varieties.

Now this type of ovary is not found in the rat, mouse, guinea pig, squirrel or Spermophilus. With respect to the guinea pig ovary L. Loeb (1911) frankly states that there are no typical interstitial cells. The rat and the mouse ovaries contain interstitial cell groups arising from the theca interna of atretic follicles; but they are transitory structures quite different from what we find in the rabbit ovary.

The reader may ask whether the interstitial tissue of the rabbit ovary has not come over from the marsupial-like ancestors, as has the uterus

[1] Contribution from the Department of Zoology, the University of Texas, Austin, No. 189.

duplex, for example, which the Lagomorphs and the Rodentia possess in common with the marsupials. The answer is in the negative; for the marsupials possess a variable amount of interstitial tissue, which is never like that of rabbit ovaries (O'Donoghue, 1916). It should further be stated that the Chiroptera also possess a highly developed though occasionally somewhat variable interstitial tissue. However, between the interstitial tissue of the rabbit ovary and that of other rodents thus far studied, there are certainly striking differences.

THE TUBAL OVUM

The classical studies on cleavage and germ layer formation in mammals were made on the most readily available material, the laboratory rodents: mouse, rat, rabbit and guinea pig. The bat should be added to the list for it was in this form that van Beneden (1870) first demonstrated the phenomenon of fertilization. The rabbit was the chief object of study for a century and a half, beginning with De Graaf (1672), who mistook ripe "graafian" follicles of the rabbit ovary for the eggs (vesicles) themselves. Excellent wood cuts of rabbit ova in cleavage are contained in the early studies of Wharton Jones (1837), Barry (1838, 1839, 1840, 1841) and especially in the famous monograph of Bischoff (1842). Embryological textbooks generally, however, have drawn upon the work of van Beneden (1880, 1884, 1912) for illustrations of the early stages in the development of the rabbit. The reader should also examine for purposes of comparison, the early stages in the eggs of marsupials, as first described by Selenka (1887) and later by Hill (1911, 1920) and then by myself (Hartman, 1916, 1919, 1922).

Such a comparison immediately discloses the fact that both rabbit and marsupial ova, when they reach the uterus, are surrounded by a thick envelope of albumen concentrically arranged about the ovum proper. Wharton Jones (1837) supposed the "gelatinous" envelope to be formed in the ovary from the liquor folliculi; Bischoff (1842) however already knew that the albumen is laid down in the oviduct. Rein (1883, p. 233) states that rabbit eggs can be seen with the naked eye in the first or ovarian third of the oviduct and again in the last or uterine third but not in the middle third. For in the first third the ova retain the corona radiata (the radially arranged "crown" of follicular cells) of the discus proligerus; and in the last third they have accumulated the albuminous envelope. In the middle third the eggs are naked as are the eggs of the opossum from the time of their discharge

from the ovary to their arrival in the albumen secreting portion (lower half) of the oviduct. Van Beneden (1880) has observed that the albumen may be laid down about certain granulations or groups of cells that serve as centers or "nuclei." I have seen the same thing in the opossum. In these cases we have what might be termed "yolkless" eggs like the hen's egg laid down about a rounded cork "yolk" experimentally introduced into the oviduct.

It is thus established that both in the rabbit and in the opossum the albuminous layer is laid down in the fallopian tube. An important function is thus performed by this organ in practically identical fashion, to judge by the result, in both marsupials and the rabbit, a fundamental community of function and doubtless inherited from a common ancestor. Thus far no special albumen secreting glands have been demonstrated in the rabbit, although Sutton and Hennig (quoted by Moreaux, 1913) described what they believed to be such glands. These were afterwards said to be mere crypts between the numerous longitudinal folds of the oviduct. It is possible that unicellular glands are responsible for the secretion of the albumen.[2] In the opossum we have found pocket shaped glands in the lower half of the oviduct which may be either albumen or shell membrane glands.

It is apparent, then, that the rabbit and marsupials both retain as vestigial characters a thick layer of albumen laid down about the ovum during its tubal journey. But what are the facts concerning other mammalian eggs, specifically the rodents? To anticipate the answer: Of all Eutherian mammals, so far as I am aware, the Lagomorpha alone have retained the habit of secreting egg-white about the ovum. In the dog, however, Bonnet (1897) finds that the uterine glands secrete a gelatinous substance that effects the first attachment (and also perhaps nutrition) of the blastocyst to the uterine mucosa. It is as if the vesicle were literally *glued* to the implantation site, in contrast to the cellular method of temporary attachment employed by the ovum of Spermophilus (Lee, 1903; Rejsek, 1904). Bonnet raises the question of homology between the gelatinous coating described by him and the albuminous envelope of the marsupial egg. In connection with the latter he mentions the mole and the horse but omits the rabbit (p. 503). Of the mole Heape (1883) distinctly says (pp. 413 and 414): "The ovum is surrounded by a thick membrane,

[2] No one seems to have made any microchemical studies on the "albuminous" layer of either rabbit or marsupial eggs. Moreaux (1913) speaks of the glandular cells of the oviduct as mucus-secreting.

the zona radiata which is in its turn, enclosed in an irregular layer of hyaline gelatine material derived from the uterus. . . . . There is no albumen deposited round the ovum during its passage down the Fallopian tube, as is the case with the rabbit's ovum." I know of no paper describing these details in the horse egg.

A study of the literature on the early development of rodents shows that in all cases the ova reach the uterus with the zona pellucida outermost; and since the zona is laid down in the ovary (most probably by the ovum itself) there is no albumen layer added during the passage through the fallopian tube. The same is true of the egg of Spermophilus (Lee, l.c.). Whether the same holds for all the rodents, the most numerous order, comprising over one-third of all known mammals (Weber, 1904, p. 470), only future study will establish. But so far as published studies go, the contrast between the tubal ova of the rabbit and the laboratory rodents is significant.[3]

INVERSION OF GERM LAYERS

If one imagine a diminutive bird or reptile egg in which the yolk has been replaced with a lymph-like fluid, he will have, at a certain stage of development, essentially a picture of an opossum vesicle. The blastoderm is superficial, that is adjacent to the albumen, and the primitive streak and embryo lie in the embryonic disc, only later to sink below the surface and become covered with the chorion and amnion. In the same way the bird embryo gradually sinks into the yolk which it digests as it grows. The opossum vesicle grows to the size of 1.5 to 1.8 mm. before the primitive streak begins to develop and in Dasyurus (Hill, 1911) the blastocyst grows to a diameter of over 4.0 mm. before this stage of differentiation is reached.

In the rabbit the cleavage proceeds as in other mammals, passing through the morula stage (van Beneden, 1880); and in the early bilaminar stage the vesicle is covered by Rauber's layer. This is, however, evanescent and disappears by gradual absorption (van Beneden, 1884)

[3] The following papers are suggested to the general reader who wishes to look up some of the more significant literature. On the rat: Huber, 1915. (This paper has an excellent bibliography.) On the mouse: Sobotta, 1895, 1903; Melissinos, 1907; Long and Mark, 1911. On the guinea pig: Bischoff, 1852; Reichert, 1861; v. Spee, 1896, 1901; Rubaschkin, 1915; Lams, 1912. On several rodents: Selenka, 1884; Lams and Doorme, 1907. Plate IV of Hubrecht's paper (1895) is instructive in connection with the next section.

so that before the mesoderm begins to proliferate, the embryonic shield and later the young embryo comes to be superficial in position. At this stage the egg is essentially the counterpart of the marsupial blastocyst. In this connection an instructive comparison can be made by an inspection of the beautiful figures presented by van Beneden (1912) for the rabbit and by Selenka (1887) for the opossum.

Development in the rat, mouse and guinea pig proceeds differently. In these forms the inner cell mass pushes into the cavity of the vesicle, so that a secondary vesicle appears within the primary one. The former then comes to have the entoderm on the *outside;* hence the process has been termed "inversion of germ layers." The "inversion" is, of course, more apparent than real. In the guinea pig the invagination proceeds to an almost ludicrous extent; so that one is reminded of the difficulty which Bischoff experienced in his study of the guinea-pig egg nearly a century ago. For this pioneer worker began his studies on the guinea pig, only to drop this form for the rabbit, a most happy change, he states, for in the rabbit the relations are much more simple and easy of interpretation.

In correlation with the inversion of germ layers is the early implantation of the rodent egg. While in the rabbit the vesicle grows large and remains free in the uterine cavity, as in marsupials, even after the primitive streak is laid down (van Beneden, 1912), in the rat, mouse, and guinea pig the egg becomes implanted long before the proliferation of primitive streak mesoderm begins. As well described and discussed from a broadly analytical viewpoint by Burckhard (1901), the egg very early eats its way into the mucosa whose epithelium melts away before it; while the decidua forms a crypt and closes up behind the egg shutting it off entirely from the uterine cavity.

The rat, mouse and guinea pig, therefore, exhibit rather specialized methods of implantation and germ layer formation, as compared with the rabbit. But many other rodents will probably be found to show transitional conditions. Thus Spermophilus "agrees with the rabbit in using the whole uterine cavity as the true decidual chamber . . . . and in the loss of Rauber's layer from the germinal area." There is also an absence of the so-called inversion of germ layers in Spermophilus. But in many details of the perforation of the epithelium Spermophilus agrees with the guinea pig" (Lee, l.c.).

It is thus apparent that the study of the embryology of the rodents has but begun. The development of representatives of but three

families, aside from the rabbits, is at all adequately known. There are many surprises in store for the embryologist, as for example the discovery by Lee of the "fixation-mass" which develops for a brief functional period at the trophoblastic pole of the Spermophilus vesicle. As Lee states "much work must be done on this order before we can apply embryological facts in any other than a tentative manner to the problems of classification."

SUMMARY

1. The rabbit ovary possesses a highly developed interstitial gland which comprises a large portion of the mass of the organ. No rodent ovary so far described is of this type.

2. The rabbit egg, like every other mammalian egg, received a zona pellucida in the ovary. During the tubal journey it received accretions of albumen laid down in concentric lamellae. This is a marsupial character. It is unknown among the Eutheria outside the Lagomorpha.

3. Functionally the oviduct of the rabbit differs, therefore, from the oviduct of other higher mammals. In the rabbit, as in the opossum, granules or small cell masses are sufficient to serve as centers about which albumen is laid down in the oviduct.

4. From the early primitive streak stage on or after the loss of Rauber's layer (absent in marsupials), the embryonic vesicle of the rabbit is the exact counterpart of that of marsupials, in that the embryo is superficial in position as in the Sauropsidian egg. It remains free for some time in the uterine cavity. In contrast to the rabbit, the laboratory rodents exhibit a remarkable invagination of the inner cell mass resulting in an apparent inversion of germ layers. The vesicle thus telescoped becomes attached at a very early age long before the primitive streak stage is reached.

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TWO NEW OCELOTS FROM MEXICO

By E. A. Goldman

In "Notes on the Synonymy and Nomenclature of the Smaller Spotted Cats of Tropical America,"[1] Dr. J. A. Allen fixed the type region of [*Felis*] *pardalis* Linnæus as the state of Vera Cruz, Mexico. To *Felis griffithii* Fischer, regarded as a member of the same group, he assigned an indefinite range in northern Mexico. This name, however, was based on a specimen in the Bullock collection which more probably came from southeastern Mexico, and seems therefore to belong in the synonymy of *F. pardalis pardalis*. Brass,[2] in 1911, published with color descriptions the names *Felis buffoni* and *Felis mexicana* for spotted Mexican cats, presumably ocelots. The name *Felis mexicana* is preoccupied by *Felis mexicana* Desmarest (1820) and *Felis mexicana* Saussure (1860). His descriptions are evidently based on individual color variations of which there are often many in the same locality. *Felis buffoni* Brass and *Felis mexicana* Brass are therefore unidentifiable.

The general range of *Felis pardalis*, transcontinental in tropical Central America, is split in southern Mexico by the great wedge formed by the Mexican highlands. From this point diverging branches extend northward along the Gulf slope to southern Texas, and along the Pacific coast to Sonora. Examination of accumulated material indicates that western and northwestern Mexico are inhabited by the hitherto unrecognized subspecies described below.

Felis pardalis nelsoni subsp. nov.
Nelson's Ocelot.

Type from Manzanillo, Colima, Mexico. No. $\frac{32642}{44565}$, ♂ old, U. S. National Museum (Biological Survey collection), collected by E. W. Nelson, February 11, 1892. Original number, 1862.

General characters.—Similar in general to *Felis pardalis pardalis*, but smaller; color averaging much the same, but black bar across underside of neck usually narrower; skull smaller and differing in details.

Color (type).—Ground color of upper parts (spaces between stripes and spots or within circular black markings) varying from near cinnamon buff to light pinkish buff (Ridgway, 1912), the former tone richest on head and neck, becoming lighter over dorsum and within black circular markings or rosettes on sides,

[1] Bull. Amer. Mus. Nat. Hist., Vol. 41, pp. 341–419, October 3, 1919.
[2] Aus dem Reiche der Pelze, p. 412, April, 1911.

while the latter tone appears mainly in irregular lines between circular black markings mentioned; upper surface striped and spotted with black as usual in the group; lighter element of upper parts passing gradually through pale buff to white, spotted with black, on fore and hind legs, and feet; under parts white, heavily spotted with black mainly across abdomen, the usual broad black bar across throat, and a narrower bar across neck; ears deep black, except usual white spots; tail irregularly spotted or ringed with black, the interspaces pale buffy above, becoming still lighter toward the tip, and dull whitish below.

Skull.—Compared with that of *F. p. pardalis* the skull is considerably smaller throughout; zygomata more squarely spreading, the sides more nearly parallel; teeth decidedly smaller.

Measurements (type).—Total length, 1140, tail vertebræ, 362; hind foot, 166. Average and extremes of 3 adult male topotypes, including type: 1067 (1002–1140); 341 (310–362); 155 (143–166). *Skull* (type): Greatest length (median projection of occiput to front of incisors), 144.1; condylobasal length, 141.4; zygomatic breadth, 96; breadth at constriction behind zygomata, 51.4; interorbital breadth, 25.3; length of nasals (median line), 29.7; greatest breadth of nasals, 18.7; alveolar length of upper incisive toothrow, 13.4; alveolar length (outer side) of upper carnassial, 12.1.

Remarks.—The ocelots of North America diminish progressively in size from south to north, especially along the Pacific coast; *Felis p. mearnsi* of Panama and Costa Rica is strikingly larger than the northern races. Examination of a considerable number of skins from various localities from Panama to northern Mexico reveals a remarkable range of individual variation in general color tone of the lighter elements, and in the size and arrangement of black markings in the pelage. Average geographic differences may be perceptible, but specimens from the same locality may vary from deep tawny to pale gray. *Felis p. nelsoni* includes within its range a long section of the narrow tropical belt between the Sierra Madre and the Pacific coast.

Specimens examined.—19, from localities as follows:

Colima: Armeria, 1; Manzanillo (type locality), 4.

Guerrero: Acapulco, 5 (skins only); Coyuca, 6 (skins only); Omilteme, 1; Papayo, 1.

Oaxaca: Puerto Angel, 1.

Felis pardalis sonoriensis subsp. nov.
Sonora Ocelot

Type from Camoa, Rio Mayo, Sonora, Mexico. No. 96216, ♂ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by E. A. Goldman, December 3, 1898. Original number, 13268.

General characters.—Most closely allied to *Felis pardalis nelsoni*, but averaging still smaller; general color somewhat paler, the black dorsal markings more widely separated by lighter areas; black cervical stripes usually narrower; skull shorter, more rounded.

Color (type).—General coloration essentially as in the type of *F. p. nelsoni*, but tone of lighter areas above slightly paler, the black markings over dorsum more widely spaced; facial black stripes present in *nelsoni* broken to form chains

of spots; black spots on legs and feet smaller; under side of neck with a narrow black bar as in *nelsoni*.

Skull.—Similar to that of *F. p. nelsoni*, but still smaller, the braincase relatively shorter, more rounded; nasals noticeably narrower; zygomata squarely spreading and teeth small, much as in *nelsoni*.

Measurements (type).—Total length, 980, tail vertebræ, 320; hind foot, 148. An adult male topotype: 1040; 351; 149. *Skull* (type): Greatest length (median projection of occiput to front of incisors), 125.8; condylobasal length, 115.6; zygomatic breadth, 85.8; breadth at constriction behind zygomata, 48.3; interorbital breadth, 24.2; length of nasals (median line), 27.2; greatest breadth of nasals, 17.1; alveolar length of upper incisive toothrow, 13.4; alveolar length (outer side) of upper carnassial, 12.1.

Remarks.—The range of *Felis p. sonoriensis* marks the northern limit, on the west side of the continent, of an apparently intergrading chain of forms extending from South America. The species as a whole, mainly tropical in distribution, here enters the Lower Sonoran life zone, individuals perhaps still reaching sporadically to extreme southern Arizona (recorded from Arizona).

Specimens examined.—4, all from the type locality.

While the North American forms of *Felis pardalis* are imperfectly known those recognizable should apparently stand as follows:

Felis pardalis pardalis Linnæus . . . Mexico (type region, state of Vera Cruz).

Felis pardalis mearnsi Allen . . . . Talamanca, Costa Rica.

Felis pardalis albescens Pucheran . . . . . Arkansas.

Felis pardalis nelsoni Goldman . . . . Manzanillo, Colima, Mexico.

Felis pardalis sonoriensis Goldman . . . Camoa, Sonora, Mexico.

Biological Survey, Washington, D. C.

GENERAL NOTES

A NOTE ON THE DISTRIBUTION OF THE STAR-NOSED MOLE

On October 25, 1923, I received for determination a male specimen of the star-nosed mole, *Condylura cristata* (Linn.), in formalin from Prof. Otto T. Walter of Macalaster College, St. Paul, Minnesota. Upon inquiry regarding the taking of this specimen I found that it was collected by Mr. C. M. Anderson, Route No. 2, Grandy, Minnesota, on December 20, 1922. This locality is about forty-five miles almost due north of St. Paul. The measurements for the specimen are: total length, 173 mm.; tail vertebræ, 73 mm.; hind foot, 26 mm.

Dr. Hartley H. T. Jackson in his review of the American moles (North American Fauna No. 38, September, 1915) gives only three Minnesota records for this species; they are Elk River, Ft. Ripley, and Margie. Since locality records for this species in Minnesota are so few and the present example increases the known distribution in that state, this additional record seems worthy of citation. The specimen is deposited in the Zoological Museum of the University of Iowa.—Dayton Stoner, *Department of Zoology, University of Iowa.*

BADGER RUNS DOWN GROUND SQUIRRELS

The following observation was made about one half mile north of the hotel at Mammoth Hot Springs, Yellowstone Park, Wyoming, at five in the afternoon of June 14, 1924.

A badger crossed the road some 200 feet ahead of me. The country was open, patches of sagebrush and tall grass alone growing along this hill top. Having supposed the badger had seen me, I was much surprised to note, after I had gone another hundred feet along the road, that he was intent on hunting ground squirrels. I stopped then, standing in quite open view on the road to watch proceedings. The badger was now among the grass tufts and the sage, ground squirrels were sounding their characteristic alarm trills on all sides, and then I saw the badger run after a squirrel, then another and perhaps a third or fourth; but each squirrel, in turn, "holed up" after a chase of a few yards at most. Then followed a longer chase, leading in my direction. The badger "ran high," holding his head well up; the ears, small as they are, noticeably thrust forward. The speed of badger and squirrel seemed about equal. There was more or less dodging about among the grass and sage. Finally the squirrel disappeared, two feet ahead of the badger, behind a tuft of grass. Here the badger stopped as though he had actually pounced on the squirrel, did a little very rapid digging with head down; raised his head, then lowered it and gave something a few shakes; turned with the squirrel hanging limply by the neck region; trotted away thus across the road and through the sage beyond.

Apparently the badger had nabbed the squirrel just when the latter had entered a very shallow burrow or other hole or had run against an obstacle of some sort. For it is certain that no considerable amount of excavating was done, the badger was in sight all the while, and the squirrel was actually caught almost as soon as overtaken.

At other times I have seen badgers abroad in the middle of the day, when they were apparently hunting ground squirrels. Finally, two young badgers which

I took from their den this spring have already proven that they are quite capable of making short work of catching and killing any ground squirrel which, for a moment, enters their three by eight feet enclosure.—EDMUND J. SAWYER, *National Park Service, Yellowstone Park, Wyoming.*

LATE INFORMATION ON THE GUADALUPE ISLAND ELEPHANT SEAL HERD

Supplementing my article, "Recent Observations on the Northern Elephant Seal" (JOURNAL OF MAMMALOGY, vol. 5, no. 4, pp. 237–242), which recorded observations made on the elephant seal beach, Guadalupe Island, Mexico, July 16–17, 1923, I can now submit some facts relative to the status of the herd about thirteen months later. Through the courtesy of the U. S. Navy, I was invited, as the representative of the Natural History Museum, San Diego, to join a party which visited Guadalupe Island and spent the day of August 30, 1924, on the elephant seal beach. The occasion of the trip, which was organized by the Zoological Society of San Diego, with the cooperation of the Mexican Government and the U. S. Navy, was the capture of four live elephant seals, two for the San Diego Zoo and two for the Zoo at Mexico City. My main purpose was to make a census of the animals for comparison with similar counts made by Dr. Hanna and Mr. Anthony on July 12, 1922, and by myself and Professor Gallegos on July 16, 1923.

By pre-arrangement, I was landed on the island in the first boat, and at once sought a vantage point well above the herd. I made three separate counts, which totalled 130, 119 and 123. The close massing of the animals at rest, together with the fact that some seals were continually entering or leaving the water, accounts for the variation in the figures. The average of the counts is 124, as compared with 366 in 1923, and 264 in 1922. Whether the decrease in the present year is due to actual diminution of the herd, or to other causes, cannot be determined until further observations on the life history of this little-known seal have been made. Beside the difference in numbers, we found a notable decrease in the number of large adults. This year there were only nine really large "yellow" animals; last year there were so many that they were not segregated in the count. On the other hand, there were six of the small "yearlings," as compared with five last year.

Four large crates had been constructed in San Diego and, after these were landed on the beach, a seal of about three or four years of age was driven into each crate. The captured animals became very excited, thrashing about, twisting and turning in their narrow crates until I thought they would snap their spines. About two and a half hours after capture, one of the animals died and was replaced with another. Several members of the party believed that it had been sick when caught, but the activity it manifested in the crate indicated, to my mind, that its death was the result of injury due to fright rather than illness. As the Mexican permit specified that only four seals could be removed from the island, the dead seal could not be brought back to the Museum for a specimen, but I did get permission from the Mexican official representative to decapitate it and preserve the skull.

The animal was a female, estimated to be about three and a half years old, and was 2722 mm. (7 ft., 3 in.) in length. Upon dissection, the sexual organs were found to be enlarged, indicating the approach of the breeding season. The

stomach contained a few teaspoonfuls of slender, wire-like worms and half a dozen squid beaks. Specimens of the stomach wall, liver, kidneys, intestines and generative organs were taken by Dr. George B. Worthington, U. S. Naval Reserves, for pathological study.

There were no distinctive characteristics of form or coloring by which this seal could have been superficially designated as a female. The four other animals that were selected at random all proved, upon later examination, to be males. But the definite presence of at least this one female opens to question the assertions recently made that all the animals on the elephant seal beach at Guadalupe are males. It is my opinion that this fact could not be accurately determined without turning over each of the seals—which is of course an impossibility. Should the animals on the beach later be found to include a proportion of both sexes, a revision would have to be made in former estimates of the number of the total herd, which assume the existence elsewhere of a number of females equal to the number of males on the beach.

The four captive seals were liberated in the pond at the San Diego Zoo within twenty-four hours after leaving Guadalupe, but in spite of the quick journey two of them died almost as soon as they were released. It happens that these two were in the uppermost crates and were exposed to the hot sun for about six and a half hours. All four animals were seen to be going through their characteristic sand-throwing motions, each time they were visited during the trip. Although the natural summer heat is intense on the seal beach at Guadalupe, it would seem that too much sun, without the relief of either sand or a short swim, is fatal to these mammals. The specimens were skinned by the Zoo attendants and I had the opportunity of examining the contents of one of the stomachs, which contained a couple of quarts of sand and a single squid beak. Of four elephant seal stomachs which I have now examined, three have contained squid beaks (and no other food) and one was empty of food—unless a small fragment of kelp leaf, in addition to the usual sand and pebbles, could be considered food.

When the skull of the female elephant seal which died on the island was cleaned, I found that the turbinates were infested with mites. Specimens were sent to Professor G. F. Ferris of Stanford University, who has described them as *Halarachne miroungae*, new species. Mites of this genus, including five or six species, he states, all occur in various seals. As yet no dermal parasites have been discovered on *Mirounga angustirostris*, although, according to Professor Ferris, the elephant seals of South Georgia Island in the Antarctic have them.—Laurence M. Huey, *Natural History Museum, Balboa Park, San Diego, California.*

TREE-CLIMBING WOODCHUCKS

Mr. St. John's article, "A Tree-climbing Woodchuck," in the Journal of Mammalogy for November, 1921, has occasioned similar reports from several of our readers. It would seem that this tree-climbing habit of the woodchuck is more common than is generally known. I wish to report a similar case which has been reported to me by a reliable witness.

During the past summer one of my students, Mr. Richard M. Smith, observed an instance of a climbing woodchuck which is here given as he reported it.

"During August while surveying a golf course at Graffenberg Inn near Caledonia, Pennsylvania, two companions and myself heard dogs barking as though they held a deer at bay. Hurrying in the direction of the sound we found two dogs had a woodchuck treed. The Woodchuck was knocked out of the tree with a stone. It had evidently climbed the tree to escape the dogs. The tree, an oak about eight inches in diameter, stood erect so that the animal did not choose it as being easily climbed. The woodchuck had taken refuge in a crotch approximately twelve feet from the ground. The animal's claws were quite sharp, and it was very large, weighing not less than fifteen or eighteen pounds. Unfortunately we had no camera available with which to secure a photographic record of the case. We did, however, take its pelt as a souvenir of the unusual occurrence of a woodchuck climbing a tree."

Upon my questioning Mr. Smith about this he told me he had never heard of this sort of case before and that as he had always lived in a country where woodchucks were common, he considered it very unusual. In speaking of this matter with my father, who has always lived in northeastern Ohio,where woodchucks are very common, he tells me that he has seen several woodchucks in trees and has known of several other instances which he did not see. From the cases reported together with the present instance it would seem that the habit is wide-spread, and that perhaps lack of observation explains its apparently unusual occurrence.—C. Lee Shilliday, *Gettysburg College, Gettysburg, Pa.*

COURAGE SHOWN BY FLYING SQUIRREL, GLAUCOMYS VOLANS

The mother flying squirrel is noted for the great devotion shown to her family. Several forestry students were trimming trees along the river May 20, 1924, when one of them sawed off a dead limb, exposing a flying squirrel's nest. The mother squirrel left the nest and climbed to the top of the tree. The student lifted the nest from the cavity and carried it to the ground.

The four young were not more than one-third grown, as their eyes were not open, and their bodies only scantily haired. The class of eight students gathered around to observe them. While they were so engaged, the mother sailed to the foot of a tree on the opposite side of the river, and immediately climbed to the top, where she made a diligent search for a suitable hole along the four large branches and trunk.

The students were surprised next to see the parent sail to their side of the river, light at their feet, and immediately climb the pants leg of the student holding the nest and young. She grasped one of the young ones in her mouth, climbed down to the ground, went to the top of a nearby tree, volplaned across the river, and carried the young one to one of the holes she had previously investigated. This trip was made four times, and each time the mother lighted near the class in approximately the same spot, and also used the same starting point on the trees each time. Only once did she ascend the wrong pants leg.

In order to check up the points of the above observation, and also to obtain motion pictures of the procedure, I visited the new nest site on June 2, 1924, and found that the young were fully haired, and a heavy load for the mother to carry. By using her mouth and fore-limbs, she rolled the young into a ball, always placing the back to her ventral side. She repeated the actions of the first occasion, except that instead of crossing the river she picked out a new home

in a tree thirty feet down on the same side of the stream. The male squirrel was not seen on any of the three occasions.—J. W. STACK, *Michigan Agricultural College, East Lansing, Mich.*

DICHROMATISM AND ALBINISM IN THOMOMYS TALPOIDES CLUSIUS

On November 25, 1923, S. C. McCampbell, a student in the Department of Zoology and Entomology at the Colorado Agricultural College, trapped a number of specimens of *Thomomys talpoides clusius* on Sand Creek, in Larimer County, about 25 miles north of Fort Collins. These specimens were all in normal pelage, with two exceptions.

One specimen was dichromatic, the other approached albinism. Roughly speaking, the dorsal part of the dichromatic specimen is a glossy blue-black, the ventral part ochraceous. The line of demarcation between the two colors is remarkably well-defined and uniform on both sides. Starting at the base of the tail it extends along the sides above the hind and fore legs, terminating about the center of the outside fold of the cheek pouches. The fore legs are the same color as the ventral surface, the upper surface of the hind legs being gray. The patch on the throat is, in this case, a white bar extending into the cheek pouches.

The measurements are as follows: Total length, 208; tail vertebræ, 43; hind foot, 28. Sex, male.

The albinotic specimen was a deep cream, lighter underneath, with large white throat-patch; tail, light; feet and legs almost white.

Measurements: Total length, 191; tall vertebræ, 50; hind foot, 29. Sex, female.

The two specimens were trapped in the same field within less than one hundred yards of each other.

The owner of the ranch on which the gophers were taken, informed us that he had trapped two or three each of the black and white ones previous to those taken by Mr. McCampbell. These we did not see.—W. L. BURNETT, *State Agricultural College, Fort Collins, Colorado.*

NOTES ON THE BREEDING OF BEAVERS

As our present knowledge of the breeding of beavers is none too complete, it seems worth while to present here the results of a limited investigation of this phase of the animal's life history as observed in Oregon.

Ordinarily beavers are not trapped for their fur in the breeding season and they should, of course, never be taken at that time of year. Until recently, however, the provisions of the game laws in Oregon permitted these animals to be killed at any time when individuals were causing damage in agricultural districts. This practice gave the writer opportunity, through coöperation with the game service, to compile a limited amount of data from the breeding females destroyed.

In all, six pregnant female beavers were examined—four from the lower Columbia region in Oregon and two from the northeastern part of the state. The number of fetal young was three in just half of the cases of pregnancy and four in the other half. This indicates a rather moderate rate of reproduction,

since there is not time for the rearing of more than one brood in a season, as with some of the smaller rodents.

The following records pertain to the material secured in the investigations:

February 8. Four fetal sacks, nearly globular, about 30 mm. in diameter. Umatilla River.

March 26. Four fetuses, eight inches long including tail; average weight 250 grams; fur on head and shoulders. Columbia River slough.

March 26. Three fetuses, five and one-fourth inches long including tail; weight 100 grams each; no fur on body. Columbia River slough.

April 7. Four fetuses, eight and three-fourths inches long including tail; weight 262 grams each; fur on head and shoulders. Columbia River slough.

April 10. Three fetuses, ten and one-half inches long including tail; weight 430 grams each; furred all over. Columbia River slough.

April 17. Three fetuses eight and one-fourth inches long including tail; weight 297 grams each; furred all over. Stanfield, Oregon.

In midsummer the writer has collected a number of young beavers by digging into the bank burrows for them and by taking them in specially constructed traps, uninjured. Their presence in the several retreats of a beaver colony may often be discovered by the low, whining cry they set up, especially about nightfall. At this season they will weigh about eight or ten pounds each, and are quite docile and easily handled. If kept in confinement, however, they must be permitted to enter the water at least once each day in order to keep in fit physical condition.—THEO. H. SCHEFFER, *Biological Survey, Puyallup, Washington.*

FIBROMA IN A VIRGINIA DEER

While hunting the past season it was my fortune to kill a doe deer afflicted with a type of tumor. The deer was fat and looked to be in good healthy condition. Had apparently had young as there was milk still in the bag. There were several tumors attached. The larger of these was attached just forward of the left shoulder near the top of neck possibly two inches below the top of spine. The second in size attached to the side of one of the udders. A third the size of a goose egg was attached to the bag, and several the size of a walnut to the bag and flank. The larger was of cauliflower growth and conical in shape, the smaller ones apparently solid and egg shaped.

The larger ones were removed and forwarded to Professor C. F. Jackson, Dept. of Zoology, University of New Hampshire, for diagnosis. Professor Jackson writes: "The growth is, I am quite sure, a "fibroma," a type of tumor. Dissolution or breaking down had started in and the animal could have undoubtedly lived but a short time longer."—E. C. BERRY, *Game Warden, Conway, New Hampshire.*

TRAINED AFRICAN ELEPHANTS

I wonder if it is generally known that the African elephant is, like the Indian species, perfectly capable of being trained. There certainly have been various statements to the contrary and I was always brought up to believe in some psychological difference between the two. Only recently on a visit to the eastern Belgian Congo I learned that there were at least forty tamed African ele-

phants doing useful work in that country, and that no particular trouble was experienced in breaking in animals up to twelve or fourteen years of age.

On my way back across Lake Victoria I met Mr. W. J. W. Roome, a secretary of the British and Foreign Bible Society, now engaged in a tribal and linguistic survey of Africa north of the Zambezi River. He told me of a herd of about thirty which he had seen working at Api in the north-central Congo some sixty miles from Bambili. He wrote an article for the "East African Standard" describing what he had seen, but I do not remember the date of its publication. However, Mr. Roome told me that the animals he saw had been broken to draw, in pairs, a four-gang plow, besides hauling wagons. They were allowed freedom to wander in search of their own food and were kept in a corral at night where more food was given them. They were perfectly tractable and gave no trouble at all, nor had any accident befallen the attendants who helped to break them. The best age at which to catch the wild ones was said to be around twelve to fourteen years.

Later on I met General Moeller (Governor General of the Congo) who bore out all that Mr. Roome had related and who showed me photographs of three other elephants doing various work at a mission station (Buta) in the Uelli district. He said that these also had been broken to harness without accident to attendants.

The problem of saving the African elephant is a difficult one at best, and with the further economic progress of the native it is going to be still more so, for you cannot educate the negro to grow produce for export and then refuse to protect him from marauding herds of game. Even now large numbers of cow elephants in Uganda have to be killed by professional government hunters who do nothing else except travel from place to place in order to drive away dangerous herds. Large elephant sanctuaries seem to be the only solution but there is opposition to their creation. And so it is interesting at this time to find that there may be some further use for elephants besides the mere taking of ivory.—John C. Phillips, *Wenham, Mass.*

RECENT LITERATURE

Donaldson, Henry Herbert. THE RAT: DATA AND REFERENCE TABLES. Second edition, revised. (American Anatomical Memoir No. 6.) The Wistar Institute of Anatomy and Biology, Philadelphia. 8vo, pp. XIV + 469; 212 tables, 72 charts and 13 figures in text. Cloth, $5.00. 1924.

Research workers on mammals welcome this second, revised and enlarged, edition of Doctor Donaldson's well-known book. It is invaluable not only to investigators who use the white rat and other domesticated mammals in their experiments, but to students of other mammals as well. Nowhere else can one find such a number and variety of tables, graphs, and citations to literature relating to a single species of mammal. The immense mass of data on the white rat not only offers a basis for comparative studies with other mammals, but is rich in suggestions of problems to be solved in other species. In fact, almost every table offers such suggestions. For example, Table 146 gives for each sex the weights of body, lungs, blood, alimentary tract, and gonads (testes and ovaries) for each millimeter of body length—the body length ranging from 47 mm. to 250 mm.; Table 157A gives body weight on age for both males and females for rats varying in age from birth to 450 days; Table 160 gives percentage of water in oven-dried entire skeleton on age in days; and so with others. While, very naturally, most of the book treats of the white rat, there are some 50 pages devoted to the wild Norway variety. Of particular use is the extensive bibliography. Although the author informs us that it "does not claim to be complete and in several directions is intentionally selective," yet he lists over 2200 titles. Since this is some 1200 more than were listed in the first (1915) edition, it gives an idea of the enormous amount of work done on the rat during the past decade.

A minor mistake perpetuated from the first edition is on page 9, where we are told that the "Mus aquaticus" of Gesner (Historia Animalium, 1551, p. 830) appears to be the form now called "Norwegicus." As a matter of fact Gesner's animal is undoubtedly *Arvicola amphibius* Linnaeus, although on the preceding page Gesner mentions, under the heading "De maiore domestico mure, quem vulgo rattum vocant" (Gesner, l. c., p. 829), an animal which is probably the Norway rat. The reviewer questions the desirability of retaining the old generic name *Mus* for the rat on the grounds that "the older term is well understood, while the new terms—Epimys and Rattus—are at present generally unfamiliar." Certainly, in this case, with the term *Rattus* used for rat, there could be no misunderstanding, and there also would be no confusion with true *Mus*, the house mouse.

One can not measure the labor and care required in making such a compilation as is presented in this book, and Doctor Donaldson has the appreciation and thanks of all working zoologists for placing within easy reach so many useful data.

—*Hartley H. T. Jackson.*

Murphy, Robert Cushman. BIRD ISLANDS OF PERU. New York and London: G. P. Putnam's Sons. 8vo, pp. XX + 362, plates 32. 1925.

One might be misled by the title of this book to the belief that it concerned

only birds and would be of interest only to ornithologists. "Bird Islands of Peru," however, is a book of general interest to naturalists and travelers. It is a delightful treatise of the natural history of the Peruvian coast and adjacent islands,—a work comparable in many respects to the natural history classics of Wallace, Belt, and Hudson. Since birds are a dominant feature of the fauna of the region, as well as being a group favored by our author in his studies, it is to be expected that birds find a dominant place in the book. Nevertheless there are excellent accounts of the physiography, meteorology, peoples (both ancient and modern), and industries; the interrelationship of the component parts of the fauna and flora, and of these with physiographical and meteorological features, are clearly stressed; and there are many valuable notes on the habits of fishes, mammals, reptiles, and other animals and illustrations of these animals, as well as birds. Probably the notes on mammals of most value are those on the sea lion and Peruvian otter, though we also find observations on dolphins, whales, and the vampire bat (*Desmodus rotundus*).

Murphy writes, in a pleasing, clear, and simple style, a book readable from cover to cover, and always entertaining and instructive. In including this brief notice, let us read a few lines from "Bird Islands": " . . . . While the fish, chiefly herrings (*Sardinella sagax*) were massed in the calm, transparent water beneath the dock, a sea lion appeared and glided about directly below us, making a clear path over and over again through the schools. As the lobo bore swiftly down upon the fishes, the latter would dart aside as if terror-stricken, but, astonishing as it may seem, they became quiet no less abruptly the instant that the enemy had passed, and they showed not the slightest tendency toward deserting the locality. To those who wax sentimental over the universal cruelty of nature, the scene would have been a convincing object lesson. Ruthlessness in nature is not necessarily cruel. It is obvious that the herrings in the Chincha strait, although from one point of view intended by nature to furnish the subsistence of the sea lion, did *not* live in fear of their relentless persecutor. It is equally clear that those fishes which has achieved the most hair-breadth escapes from the lobo cherished no unpleasant memories of their danger, not even for the briefest period; and that, as individuals, they acquired no profit by their experience other than their momentary safety. Life and death to them meant nothing; escape represented only the fortuitous and instinctive functioning of a reflex produced by an external stimulus (*i.e.*, the seal). Time and time again, while I looked on from a distance of ten feet, the torpedo-like lobo shot among the fish and took toll. The reaction, both individual and collective, was invariably the same—a violent spurt which carried the fish a yard or two ahead, and then a prompt return to lethargy."

—*Hartley H. T. Jackson.*

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——— Serridentinus and Baluchitherium, Loh formation, Mongolia. Amer. Mus. Novit., no. 148, pp. 1–5, figs. 1–2. November 11, 1924.

——— Parelephas in relation to phyla and genera of the family Elephantidae. Amer. Mus. Novit., no. 152, pp. 1–7, figs. 1–2. December 20, 1924. (New:

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